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# THE SCIENTIFIC MONTHLY

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# THE SCIENTIFIC MONTHLY

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## THE PSYCHOLOGY OF DAYLIGHT SAVING


By Professor GEORGE T. W. PATRICK

THE STATE UNIVERSITY OF IOWA


NOTWITHSTANDING the President's veto, a bill repealing the daylight saving law in the United States was passed by an overwhelming majority in the Senate and House. One senator had on his desk a petition for the repeal of the law signed by more than one hundred and twenty thousand names, all from one state. In a typical mid-west town of twelve thousand, a straw vote revealed more than ten to one against the plan. Daylight saving in America thus passes for the moment into history and by many unthinking people will no doubt be remembered as a crazy freak of theorists or an unholy attempt to meddle with the clock.

Nevertheless, daylight saving is sure to be revived and there are already strong movements throughout the country to introduce it again next summer in separate communities. Furthermore, the statement may be made and easily maintained that the daylight-saving plan is thoroughly sound and desirable both from the economic and scientific standpoint, wholly conducive to public welfare and practically free from serious objections.

The formidable array of arguments marshaled against the plan on the floor of Congress were riddled with fallacies, which a little patience and candor might have exposed. Any careful and serious consideration of the subject was prevented by a wave of reaction and the clamor of the farmers of the middle west who were inconvenienced by the law. It was simply another instance of a clamorous minority and an indifferent public.

Now that the law has been repealed and we have leisure to study the subject more carefully, it will be instructive to examine some of the grounds for daylight saving and some

of the arguments against it. There are also certain curious psychological factors in the case, which it will be interesting to observe.

On the face of it, daylight saving seems to be an unmixed gain. The law provided that the clock should be advanced one hour every spring and set back one hour in the fall. Unfortunately in this country the change was made to take place too early in the spring and too late in the fall, a mistake that should be remedied in any future attempts. Now, since few people get up at daylight in the summer, the daylight saving plan gives us an extra hour of sunlight in place of an hour of artificial light in our waking day. Since sunlight is cheaper than gas or electric light, being absolutely free for the taking, and since it is also brighter and healthier, and since, furthermore, the plan involves no change in the routine of our daily life, merely substituting one hour of sunlight for one hour of darkness, it would seem at first view that there could be no possible objection to it, except on the part of the gas and electric companies.

If we note also the fact that the plan has been adopted by practically all the European countries, resulting in an enormous saving in expense in artificial lighting and adding apparently to the health, happiness and comfort of the people, the mystery deepens as to the cause of the objection to it in this country. The subject offers a unique chapter in popular psychology and reveals certain new features not hitherto brought into the discussion. Although sunlight is cheaper, healthier and brighter than artificial light and more convenient even than pressing an electric button, it appears that people *prefer* the artificial light and the reasons for this preference have to be taken into account. If these reasons are valid, then, in spite of all the conspicuous arguments for the plan from the economic, hygienic and social point of view, we might still have to revise our opinion as to the value of it.

But first let us orient ourselves on the whole subject. It has been determined that adult men and women need about eight hours of sleep daily. This leaves sixteen hours of the twenty-four for our waking life. In the platform of labor parties, for instance, we read of eight hours for work, eight hours for sleep, and eight hours for recreation. Now it happens that in the summertime in the latitude of New York and our great middle west, the daylight day is sixteen hours in length. It is light at about four in the morning (that is, by the old

time) and darkness falls at about eight in the evening. After eight o'clock it is necessary to use artificial light. Thus the natural daylight day in the summer months exactly fits the human working day and there is no doubt that during the age-long history of man on the earth, reaching back hundreds of thousands of years, he has been accustomed to rise at daylight and go to sleep at dark, as do the birds and other lower animals. Only the predatory birds and animals, who have found it to their advantage to prey upon the quiescent nocturnal life, reverse this order.

Gradually, however, with the invention of artificial light, and especially since the invention of the electric light, there has come about a displacement between the daylight day and the human day, so that now we rise two or three, or even four or five hours, after daylight and remain up two, three, or even five or six hours, after dark, using artificial light. This displacement has taken place in human history very recently, just yesterday, relatively speaking. Even as late as the time of the Greeks and Romans, there was relatively little displacement. In one of Plato's dialogues the young man Hippocrates thumps loudly on Socrates' door before daybreak, eager to hasten to the place where Protagoras, the celebrated sophist, was instructing Athenian youth.

The reasons for this displacement of the human working day are interesting. We shall inquire presently into this curious bit of psychology. But the displacement itself is going on faster than ever at the present time, owing in large part to the discovery of the convenient, brilliant and fascinating electric light. Every year it seems to be a little harder to go to bed or to get up at the old accustomed time. Automobiles, unlike the horse, travel as well at night as by day and keep increasingly late hours. College and high-school students study later at night or engage in social activities. To go to bed early is not just the thing. It is a little out of date. To meet the requirements of our complicated modern life, more and more industries continue through the night, for instance, railroads and steamship lines, hotels, police service, news collecting and newspaper printing, etc. Quite apart, however, from these necessary night occupations there is an increasing tendency to shift the day farther and farther forward. Without doubt the number of people who sleep till noon is constantly increasing. If the matter is left to adjust itself, one naturally wonders how far we shall go in the substitution of night for day. Will day and night finally be wholly transposed?

Apart from psychological considerations, this displacement of the day seems to be the purest kind of folly. The morning hours with the noisy singing of the birds and the streaming light of the sun are not well adapted to sleeping. At nightfall, which in the summer takes place at about eight o'clock by the old time, nature is still and the conditions for sleep are perfect.

This loss of the morning sunlight was so evidently a net loss to the nation, that the daylight-saving plan was devised to correct it. It does not attempt to correct the whole discrepancy between the natural day and the human working day, but only one hour of it. And it attempts to do this not by making any change whatever in our daily program, but simply by setting the whole program one hour earlier by the sun, leaving it precisely as before by the clock. It is as if a good God had said:

> My people have shifted their day so that they lose two or three hours of the precious morning sunlight and have to use artificial light in the evening. How shall I correct this? In order not to disturb their habits or their customs or their clocks, I will quietly order the sun in the summertime to rise one hour later and set one hour later at night. This will bring their day and my day more nearly together and many of them will hardly know that any change has been made. They will simply enjoy the sunlight an hour longer every evening.

Of course, the same effect could be accomplished by advancing in the middle of some dark night every clock in the land. This was the way that Congress attempted to attain the desired end. So far as the daylight-saving law has failed of its full benefits, it has been because many of us did not understand that we were to make no change in our daily schedule. We should have gone on precisely as before in every detail. If we had been accustomed to rise at six o'clock, breakfast at seven, go to school at nine, lunch at twelve, dine at six and retire at ten, we should have gone on doing all these things at precisely the same time by the clock. Then no change or disturbance whatever would have taken place in our lives, only we should have enjoyed an hour's additional sunlight in the evening.

True, the great majority of us did this and we have found the added sunlight the greatest benefit. We have enjoyed our morning's sleep better because it was dark and quiet. Then the day has followed exactly as before, except only that when we have gone to work at the usual hour the sun was not so high nor so hot and, it being summertime, this has been greatly appreciated, for the last hour of our work in the afternoon had often been very hot and uncomfortable, and now we have been free during this last hour. This has given us after work

at night or after school a delightfully long evening for play or sport or picnics, or, if we prefer, for work at home. The home garden has become more popular and this added hour of sunlight after working hours has given many of us an opportunity to work in our gardens or with our flowers. To be sure, under the old plan we could get up in the morning and work in the garden, but the gardens in the morning were wet with the dew and work was unpleasant. The result has been a very large increase in the number and size of our gardens, with a corresponding increase of wealth and health.

Now that the war is over, if the daylight-saving plan should be continued, decided benefit in respect to morals may also be expected, for darkness is a cover for every evil thing. We know how our cities and towns in the interest of morals flood the streets, alleys and parks with electric light. Sunlight accomplished this end so much the better.

Still greater will be the benefit to our national health. Sunlight is the enemy of almost every form of disease. The substitution of an hour of daylight for an hour of artificial light means for many of us another hour of outdoor life with outdoor sports or outdoor work. An hour of lamp light means an hour of indoor life. Since some of our most insidious modern diseases are the results of our increasingly sedentary and indoor life, the benefit of the daylight-saving plan to our national health must be obvious.

Incidentally too there will be a decided benefit to the eyes. Our modern life involves so great a strain upon the eyes in reading and in all manner of fine work, and so much of this reading and writing is done at night by the aid of artificial light, that the substitution of an hour of sunlight for gas or electric light will be of supreme value to us. In fact we are coming to realize that something must be done to relieve the strain upon the eyes. Statistics from our recent military draft showed that nearly thirty-five per cent. of our young men were physically unfit for military service, and of the various defects causing this unfitness defects of the eyes stood at the head of the list, more than one fifth of all the rejections being due to this cause.

While no doubt the greatest advantage of the daylight-saving plan is in the matter of health in the substitution of sunlight for artificial light one hour each day in the summer, nevertheless it is the saving in expense which appeals to us most forcibly. Artificial illumination in homes, parks, streets,

hotels, railroad stations and in all shops, offices, stores, etc., that are open in the evening in summertime must begin under the old plan about eight o'clock in midsummer and earlier in the spring and fall, while under the new plan it begins an hour later. The city of Vienna is said to have reduced its gas consumption in one summer by the daylight-saving plan by 158 million cubic feet, resulting in a saving of $142,000. One of the large electric-lighting establishments in Paris reported that when the clock was turned back in October its nightly peak load of 35,000 kilowatts of current jumped in a few days to 53,000 kilowatts. It is estimated that England saves $12,500,000 in coal annually by the new method and the saving for the United States is estimated at $25,000,000 annually.

The coal supply of the world is not going to last forever. Many think that the shortage will soon begin to be felt in this country. Coal for keeping us warm in winter and in lighting our homes in winter is indispensable. To lie in bed in the morning when the sun is shining and then use our precious supply of coal for illumination at night would seem to be an inexcusable extravagance. Conservation of coal will soon be absolutely necessary. It may well begin by daylight saving. The saving in coal, however, is only a part of the total financial gain of the new daylight plan.

If under such circumstances it seems difficult to explain the opposition to the plan, the difficulty is increased when we recall the general favor with which the plan has been received in European countries and indeed with large classes in America. On June 14 of the present year *The Literary Digest* published the results of a wide inquiry among labor unions and workingmen's organizations as to the opinion of laboring men about the daylight-saving law. With very few exceptions wholly favorable responses were received from mine workers, electric workers, laundry, brewery, flour, cereal, flint glass, garment, soft drink, and boot and shoe workers' unions and from organizations representing machinists, hod carriers, blacksmiths, barbers, pressmen, and from hotel and restaurant workers. Furthermore, the new plan appears to be very favorably received by physicians, lawyers, university men, public-school teachers and business men. It gives them longer summer evenings for gardening, motoring, golf, etc.

The immediate cause of the attempt of Congress to repeal the law was the loud and vigorous protest of the farmers against it. If we consider the unusual and unparalleled prosperity of

the farmers during the time in which daylight saving has been in force, and furthermore the rather unconvincing character of the arguments which they brought against it, and still further the very feeble fight which advocates of the plan offered in its defence, it becomes evident that there were other factors involved in the situation. One of these factors no doubt was the extreme conservatism of the American people and their dislike of any legislative action which seemed to interfere with the established routine of their daily lives. The change to standard time, for instance, which was effected by act of Congress some years ago and which has resulted in great benefit and convenience, met with serious opposition in many quarters and it is said that the old time is still adhered to in some localities. Again, all attempts to discard our antiquated and inconvenient system of weights and measures and to substitute the scientific metric system have met with opposition. For a body of legislators at Washington to interfere with the affairs of our daily life and tell us what time to get up and what time to go to bed was carrying things too far. As a war measure we could submit to this or any indignity, but not in time of peace. When the daylight-saving scheme was first brought forward in England and America it was opposed even by men of science, and if the farmers have offered unsound arguments against it, so did the scientists. It was argued, for instance, by the English journal, *Nature*, that England should not adopt the plan for the reason that it had been adopted by Germany and that Germany had probably adopted it because England had not! This writer closed his editorial with the remark that daylight saving would be a leap in the dark! This was every bit as bad as the farmer who wrote to his local paper that the crazy daylight law should be repealed because working in the corn-field in the early morning brushed the dew from the corn. A slight computation would have shown this writer that the chances of any given hill of corn having the dew brushed from it *once* during the summer, owing to the earlier hour of the farmer's day, would be only one in ten. Many letters were written by farmers and farmers' wives to local papers protesting against the unholy interference with God's time.

But let us consider the real arguments against the plan of daylight saving as they were presented by the farmers through their representatives in Congress. One objection was that the hottest time of the day was between twelve and one o'clock (according to the old time) and under the new plan the farmer

and his horses must be back in the field during this hour. This argument has all the appearance of being manufactured in some newspaper office, for any observing farmer knows, as any thermometric chart will show, that the hottest part of a summer's day is not at that time, but between two and four in the afternoon, usually between two and three. In midsummer in the Mississippi Valley the maximum temperature occurs at about three o'clock, while even at six the temperature has fallen often only three degrees Fahrenheit. The great difference between the temperature of the first morning hour of the working day and the last evening hour, reveals the advantage of the new plan to all workers during the hot weather, since it substitutes the cool morning hour for the hot evening hour.

Second, it was complained by mothers, not only in the country but in the city, that under daylight saving the children could not get ready for school in time, since it began an hour earlier. The reply to this is, of course, that school does not begin an hour earlier but at precisely the same time, namely, at nine o'clock. If the children were accustomed to get up at five, six, seven or eight o'clock, they could continue to do so under the new plan and would have the same time for preparation as before. In any case they would not have to get up before light, for it is light at five o'clock by the new time in midsummer and at half past five on May 1. It is probable that the children slept later under the new plan and they slept later because they sat up later. In other words, they did not fully accept the daylight-saving plan but made a change in their hour of retiring, when it came into effect. Indeed if school began at seven, there should be no difficulty in getting there on time. It's a matter of habit. The church hour has been gradually put later and later until now it is at eleven o'clock, and yet many people are late for church.

Third, it was complained that the dairymen had to get up earlier in the morning, perhaps before daylight, in order to get the milk ready for the morning trains. Incidentally one can not help noting here a psychological factor, namely, our willingness to use artificial light in the evening but our dislike to using it in the morning. No doubt the advancing of the clock has made it necessary for some dairymen to get up before daylight and has caused them considerable inconvenience. But for these dairymen to ask that the rest of the hundred million people of this country should sleep another hour every morning in order that they, the milkmen, should not have to get up before day-

light would be unique, to say the least. If, for instance, we imagine a great nation accustomed to get up at daybreak and go to bed at dark and living in large cities and demanding fresh milk for their breakfasts, some one would have to get up before light to supply the demand. This inconvenience could no doubt be avoided if all the people except the dairymen should sleep several hours later in the morning, but no sane man would propose to remedy the difficulty in this way.

Seen in this light, the other difficulties experienced by the farmers fall into their proper perspective. In advocating the repeal of the law, the farmers have laid special stress upon two difficulties. First, owing to the dew, the early morning hour is not favorable for farm work. And second, if to avoid this the farmer begins and ends his day's work at the former time, his hired men make trouble, since they wish to stop work when the town and city people do. Furthermore, if the farmer works an hour longer than the city people, he is late for any entertainment or meeting which he may wish to attend in the city in the evening. As these difficulties were presented to the country, they were offered as separate and cumulative objections. They are, of course, alternatives. If the farmer begins his work an hour earlier than formerly and experiences trouble from the dew, he does not experience the other troubles, and *vice versa*.

Perhaps none of these difficulties is so serious as was imagined. The complaints about the dew came principally from the farmers of the Mississippi Valley and pertain only to haying and harvest time. The dew does not interfere with other farming operations, such as plowing, disking, seeding and planting and cultivating corn. During harvest time, as the dew is sometimes on the grass and grain until nine or ten o'clock, it is often in any case necessary for the farmer to begin and end his work at later hours. The need of synchronizing farm and city hours of labor during three or four weeks of the year is not so great as to ask a whole nation during the whole summer to begin its day's work an hour later in the morning and live by artificial light an hour later at night.

It was also loudly proclaimed by the opponents of the daylight-saving law that if the city people want to get up earlier in the morning, they can do so, but let them not meddle with the clock. But if the city people got up earlier, they would begin their working day earlier and the farmers' two difficulties would appear as before. And it should be remembered that it is a question of social welfare in which everybody is interested

and that the habits of the people will not be changed, although theoretically they could be, without some concerted legislative action. It is probable that the farmers themselves, when the matter has been accurately presented to them, accustomed as they are to rise and retire early, will welcome a change which shall encourage other people to do the same.

It turns out, therefore, that the objections to the daylight-saving law are rather petty and not of serious moment. Perhaps the strongest objection is one which apparently was not urged by the opponents of the law, namely, that a great many people in America have to sleep in upper rooms which are very hot in the evening and that they therefore sit up until it is cool and so under the new plan do not get enough sleep. There are no doubt ways in which this difficulty may be met and it is not of such seriousness as to weigh against the exceeding great benefits of the new plan.

After all, the psychological factors of the situation are the ones which present the greatest obstacles to daylight saving. There is a certain fascination about artificial light and a certain human predilection for night life that must be reckoned with. Whatever the reason for this preference may be, it is so strong that if by legislative action we were to set forward the clock one hour both summer and winter, in the long run it is probable that nothing would be gained. We should soon be getting up an hour later by the clock, should go to school at ten, to church at twelve, and our whole daily schedule would be correspondingly advanced. It is only by adopting the plan for the summer months that any really permanent advantage may be gained.

But what is the cause of this shifting forward of the human day so that it no longer corresponds with the solar day? Why do we tend to get up later and go to bed later as the years go by? There are several reasons and the psychologists are able with considerable success to fathom them. The first is a very simple and evident reason. As life becomes complicated and interesting, it is difficult to get through with the duties of the day in the usual time and so we sit up later at night, and then, in order to obtain the necessary sleep, we have to get up later the next morning—and the habit grows.

Another minor cause is found in the fact that at night, when most of the world sleeps, some will find it to their advantage to be awake. Just as certain predatory birds and animals roam or prowl at night to take advantage of the sleepers, so certain human occupations, lawful and unlawful, flourish under cover

of the darkness. Certain kinds of crime flourish at night and night is proverbially the time for love making in all its phases. Many students, writers, inventors, etc., work at night simply because it is quiet and greater mental concentration is possible. Some night workers report a peculiar feeling of power and sovereignty at night, as though one possessed the world. Obviously, however, these advantages of night work will disappear in proportion as the night hours are used by all. Already the morning hours are becoming the really quiet time for work. Those who find the night hours better for concentrative or creative work have formed an expensive mental habit. If the habit were reversed, the morning hours after refreshing sleep would be found the most productive as well as the most economical.

But probably the real reasons for our ever increasing night life are of a profound psychological nature. There are two distinct principles involved here. First, artificial light exercises upon us a peculiar fascination not possessed by sunlight. This is due to certain mental associations coming down from the primitive life of man. Fire is the original source of artificial light and fire and light are associated in the mind. The campfire or the fire on the hearth suggest feasting and joy after the labor of the day and in winter suggest warmth and comfort. After the strenuous labors of the day in forest and field comes the pleasant relaxation of the evening, and whether this takes the form of feasting or dancing or music or the telling of tales, the camp-fire is the center of this joyous social life. This deep-seated association fixed by centuries of ancestral habit explains that peculiar feeling of pleasure which we have when the lights are lighted at night. When theatrical performances are held by day, no matter how well lighted the theater may be, we all prefer to darken the windows and use the electric lights, while the lure of the great city is partly due to the glitter of the brilliantly lighted streets and places of amusement.

The other reason for the peculiar charm of night life is due to still more recondite mental associations. To live by night and sleep by day is a sign of class distinction. The man who works at common manual labor must rise with the sun and go to work. Not so the leisure classes. They can rise when they choose and sit up as late as they wish. Night life, therefore, gives what Professor Thorstein Veblen would call "honorific status." It is only another case of "conspicuous waste." To go to bed early is not just the thing from the social point of view. To sit up late is a sign of a certain "invidious distinction." To

sit up very late or to lie in bed till noon is a sign of affluence. We often boast of late hours but we are a little ashamed of going to bed early. In Russia, for instance, before the war, class distinctions were quite marked in this way. Banks, business and professional offices, etc., opened at ten o'clock. Lunch was served at two, dinner at seven, evening tea between eleven and twelve, regular social activities continued till two or three and special social functions till four or five in the morning. The laboring classes, on the other hand, must get up early and retire early at night. Night life thus became a form of "ostentatious display."

On the whole, then, it appears that the motives which have led to the substitution of the night life for the life of the sunlight day have little or nothing to recommend them, whether we consider them in their economic, hygienic, moral, social or psychological relations. They rest upon an obsolescent social philosophy and outgrown anthropological habits. They can not prevail at a time like this when we recognize the dignity of labor, the importance of health and the need for conservation of our material resources. The daylight-saving movement is therefore distinctly a modern movement, representing just what the present age stands for, namely, health, economy, conservation and common sense.

# THE SNOWFALL OF THE UNITED STATES

By Professor ROBERT DeC. WARD
HARVARD UNIVERSITY

## The Economics of Snow

THE margin of temperature difference between rain and snow is a narrow one. It is, however, one of the most critical points in man's relation to the atmosphere, because of the fundamental differences in the economic effects of rain and snow. Snow, especially the deep snows which lie for weeks and months on the mountains and plateaus of the semi-arid West, furnish a slower and therefore a more lasting natural supply of water for power, for irrigation, and for general use than does rain, which has a quick run-off. In the drier sections of the United States many of the most important problems with which engineers have to deal, whether in connection with railroad construction and operation, or hydraulics, or irrigation, or general water-supply, are connected with the depth and conditions of snowfall, and with the amount of water which its melting will supply. In California, the mountain snowfall has well been termed the life-blood of the state, and the same is true of most of the vast territory west of the Rocky Mountains. The farmers throughout the districts of deficient precipitation are deeply concerned with the amount of winter snowfall, for the melting snows supply most of the water needed for irrigating the crops. A winter snow-cover prevents deep freezing of the ground; protects grasses and fall-sown crops, and provides spring moisture for growing vegetation.

When sufficiently deep, and more or less permanent, snow makes sleighing possible, and greatly facilitates lumbering operations over the forested sections of the northern and north-eastern states. Heavy winter snows, on the other hand, interfere with railroad operation, sometimes causing serious and expensive interruption of transportation, and involving great expense for the removal of snow from steam and electric railroads, and from city streets. At the same time, such conditions furnish employment to thousands of men. An open winter, with light snowfall, means a saving of millions of dollars to the railroads and cities in the snow-belt. In the latitudes of heavy snowfall, snow-sheds, snow-fences and snow-ploughs are essen-

tial to a reasonably uninterrupted railroad service. The demand for all kinds of rubber footwear in the states where snowfall is a common winter characteristic has given rise to one of the important manufacturing industries of the snow-belt. The use of snowshoes and of skis, for winter sports as well as for ordinary means of locomotion, is another result of a winter snow-cover.

## THE MEASUREMENT OF SNOWFALL

The accurate measurement of snowfall presents many difficulties, and no reasonably simple, practical and satisfactory method for general use has yet been devised. Most of the available records are still of rather doubtful accuracy. What is needed is careful determination both of the depth of snow as it falls and also of the water-equivalent of the snow when melted. The widely-quoted average ratio of ten inches of snow to one inch of water is subject to very wide fluctuations, for it depends upon the varying density and quality of the snow. The essential difficulty in obtaining accurate measurements by means of any ordinary form of gauge results from the effect of the wind in preventing the snow from falling into the gauge. In calms, or during light winds, there is little or no error, but when there is much wind such a gauge, unless properly protected or screened in order to break the force of the wind, will give too small a catch, the deficiency becoming greater as the wind velocity increases.

In view of the economic importance of the amount of water available for irrigation and power in the western states, considerable study has been made, especially during recent years, of the whole problem of the more exact determination of the depth of snowfall and of its water-equivalent. Various improvements in snow-gauges which weigh the snow directly have been made by Marvin, Fergusson, Rotch and Fitzgerald, but there still remains the difficulty of securing an accurate catch. Professor Charles F. Marvin, the present Chief of the Weather Bureau, has devised a large shielded weighing gauge which has given fairly satisfactory results at some stations, but there have been difficulties with it on account of the blocking of the top of the collector during wet and sticky snows and by frozen snow, as well as by reason of its being crushed by the weight of very deep snow. In snows which accumulate to a depth of many feet a very large gauge becomes necessary, and there are many difficulties which are not met with where snows are light. In the regions of very heavy snowfalls on the higher unin-

habited elevations of the western states there is the difficulty of visiting the gauges during the winter, and of constructing a gauge of some sort which may catch, and record, the snowfall of a whole season. Snow "bins" of various forms, standpipes, platforms, and other devices have been tried, without much success. Various methods have also been used for measuring the depth of snow by means of snow-stakes, and of melting cross-sections of snow in order to determine the average density of the snow cover. Professor J. E. Church, Jr., of the University of Nevada, has obtained good results by using snow-stakes, and by cutting out and measuring tubular sections of the deep snows of the Sierra Nevada by means of his improved "snow sampler."[1]

In this instrument, vertical snow cylinders are cut out by means of several sections of tubing of small diameter, and the water content of this sample is determined by weight, the dial of the spring balance being graduated to indicate the depth of water instead of its weight. In order to ascertain in advance the amount of water which will each year be available from the melting mountain snows, surveys have been made of type watersheds in selected areas of the West, and the amount of snow on adjacent watersheds is then estimated. Surveys of this kind will undoubtedly be greatly extended by the Weather Bureau in the near future.

In the matter of forecasting the amount of water available from snow, the rate of melting of the snow, as well as the amount of evaporation from the snowfields and from the surfaces of water storage basins are obviously of great consequence. Some years ago (1908) Professor J. N. Le Conte devised a method for determining the mean rate of melting of the snows in the Sierra Nevada Mountains of California.[2] In order to obtain the true rate of melting, the average date at which the snow is of a certain depth is determined. The mean curve of melting is then compared with the actual curve of a given year. When the actual curve falls below the mean as a whole the season is dry, the rains are likely to be low, and travel in the mountains will probably be easy as early as July. When, on the contrary, the actual curve of melting is slower than the

[1] J. E. Church, Jr., "Snow Surveying: its Problems and their Present Phases with Reference to Mount Rose, Nevada, and Vicinity," *Proc. 2d Pan-Amer. Sci. Congr.*, Sec. II., Vol. II., 8vo, Washington, D. C., 1917, pp. 496–547 (a general discussion of the problem, with references to the literature).

[2] J. N. Le Conte, "Snowfall in the Sierra Nevada," *Bull. Sierra Club*, June, 1908.

mean, it may be inferred that the snows will last longer, and that high water will come later. This matter has been discussed by Professor A. G. McAdie, who has designed a model by means of which the actual curve of melting for a given season may be compared with the mean curve, and thus the probable date of the disappearance of the snow may be determined.[3]

Professor A. J. Henry, of the Weather Bureau, has investigated the weather conditions which may modify or control the disappearance of the snows in the High Sierras of California.[4] The most pronounced "snow flood" in the United States is that which passes annually down the Columbia River and which is due almost wholly to the melting snows on the mountains of the Columbia drainage basin. Otherwise "snow floods" are generally rare in the United States, flood conditions being usually brought about by a combination of snow-melting and of heavy rainfall. In the high Sierras, the most favorable weather conditions for the conservation of the snow-cover are low temperatures and little wind movement. When these conditions prevail, the average loss by evaporation is about three quarters of an inch per day. Relatively high temperature, active wind movement, and abundance of strong sunshine are the most favorable conditions for the conservation of a snow cover. Under these conditions, the loss of freshly fallen snow may average ten inches a day, and of old snow, three to four inches. In connection with the disappearance of snow, the influence of forests upon the rate of melting deserves more extended study than it has yet received. To cite but one illustration, it appears that in the case of the yellow pine forest near Flagstaff, Ariz., the spring rate of melting in the forest is noticeably slower than that over the adjacent grass and farm-land park area.[5] The observations of snowfall at the regular stations of the Weather Bureau are made by means of ordinary gauges, the amount of melted snow being included in the general record of "rainfall." In addition, the number of inches and tenths of inches of snowfall for each 24-hour interval is determined as

[3] A. G. McAdie, "Snowfall at Summit, Cal.," *Mo. Wea. Rev.*, Vol. 38, 1910, pp. 940–941; "Forecasting the Supply of Water for the Summer from the Depth of Snow," *ibid.*, Vol. 39, 1911, pp. 445–447; "Forecasting the Water Supply of California," *ibid.*, Vol. 41, 1913, pp. 1092–1093; "The Principles of Aerography," 8vo, Chicago and New York, 1917, pp. 226–229. See also J. N. Le Conte, *loc. cit.*

[4] Alfred J. Henry, "The Disappearance of Snow in the High Sierras of California," *Mo. Wea. Rev.*, Vol. 44, 1916, pp. 150–153.

[5] A. J. Jaenicke and M. H. Foerster, "The Influence of a Western Yellow Pine Forest on the Accumulation and Melting of Snow," *Mo. Wea. Rev.*, Vol. 43, 1915, pp. 115–124.

accurately as possible by measurements made at places where the snow is of average depth.[6]

These observations have been used as the basis of the snowfall maps of the United States hitherto published.[7]

## The Mean Annual Snowfall Map of the United States

The standard snowfall map of the United States at the present time was constructed by Dr. Charles F. Brooks and originally published in England.[8]

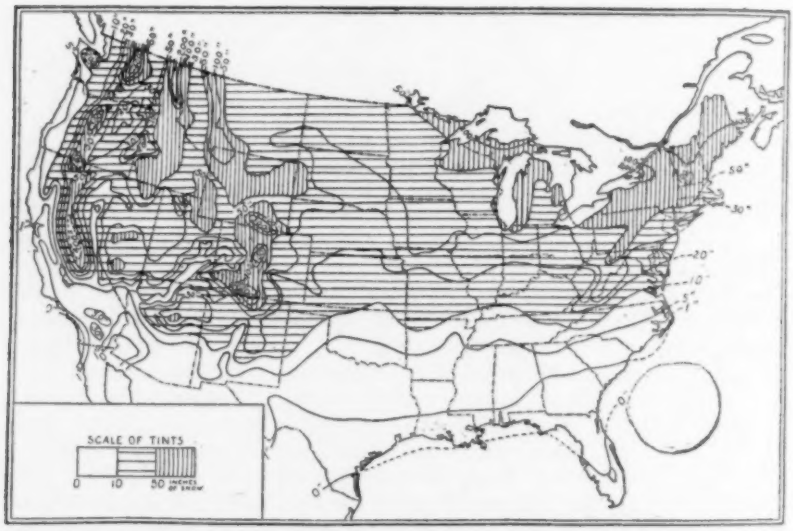
It is here reproduced, with some slight modification, for the first time. The map is based upon the snowfall observations from July, 1895, to June, 1910. In all, the data for over 2,000 stations were used. Of these, 159 had a continuous record for the fifteen years, and these were given the most weight. The data for stations with shorter records were given less and less weight as the length of the period of observation decreased. In previous maps the observations used came mostly from the larger cities, the majority of which are not far from sea-level.

[6] Current data regarding snowfall may be found in the "Annual Reports of the Chief of the Weather Bureau"; in the *Monthly Weather Review* (including the *Annual Summary*), and in the monthly and annual reports of "Climatological Data" which are issued for the section centres, each section as a rule corresponding to a state. Averages, covering periods of years, may be found in the "Summaries of Climatological Data by Sections," and in A. J. Henry: "Climatology of the United States," *Bulletin Q*, U. S. Weather Bureau, 4to, Washington, D. C., 1906. Both of the last-named publications also contain brief statements concerning snowfall in their texts. Maps showing the depth of snowfall for each month appear regularly during the winter in the *Monthly Weather Review*, and the depth of snow on the ground is charted weekly during the season in the *Snow and Ice Bulletin*. All of the above are regular publications of the Weather Bureau.

[7] The first snowfall map of the United States was constructed by Professor Mark W. Harrington on the basis of data covering the general period 1884 to 1891. A reproduction may be found in F. Waldo, "Elementary Meteorology," 8vo, New York, 1896, Fig. 108, p. 344. A later chart, for the general period 1884 to 1895, the data covering varying numbers of years from 3 to 11, by Professor A. J. Henry, was published in the *Monthly Weather Review*, Vol. 26, March, 1898, Ch. XI., Text, p. 108. A note is appended to the chart, stating that the snowfall of the Sierra Nevada and Rocky Mountains is "much greater" than is shown on the chart. Monthly charts, showing the average depth of snowfall from October to May, inclusive, based on records of varying lengths from five to twenty years, mostly not over seven years (1884–1891), were published in 1891 by Professor Harrington (*Bulletin C*, U. S. Weather Bureau, 1894, Pl. XVIII., text, pp. 16–17).

[8] Charles F. Brooks, "The Snowfall of the United States," *Quart. Journ. Roy. Met. Soc.*, Vol. 39, 1913, pp. 81–84, Pl. II.

Hence the snowfalls on the mountains and at the higher elevations generally were not indicated. In the case of the present map, the author has made use of the observations which have been obtained at the higher altitudes as well, and, taking account of the probable effect of the topography, has for the first time shown the actual conditions of snowfall over the whole country with as close an approach to accuracy as is possible with the observations which were used. When more numerous, and later data come to be taken into account, a more detailed and a more accurate map can, of course, be constructed.




MEAN ANNUAL SNOWFALL MAP OF THE UNITED STATES. (C. F. Brooks.)

The lines on the accompanying map show the average annual depth of snowfall, in inches, on the general basis of 15 years of observation. They do not, therefore, indicate the maximum or the minimum depths which have been recorded in this period; nor the depths in any single year; nor does the 0-inch line show the extreme limit to which snow has ever fallen. It must, furthermore, be remembered that the amount of snowfall varies greatly, and very irregularly, from year to year. Years of abundant snows, well exceeding the average depth, alternate irregularly with years of deficient snowfall. This variability depends on the length and the severity of the winter, and on the number and the intensity of the snowstorms.

## General Controls of Snowfall; Snowstorm; 24-Hour Snowfalls

The major controls of snowfall in the United States are the temperature; the season of precipitation; the frequency and intensity of winter storms; the topography; proximity to primary sources of moisture-supply, such as the oceans and the Great Lakes, and the exposure to damp winds. The heaviest snowfall is to be expected where the winter season naturally has abundant precipitation, and where the temperatures are low enough to give snow instead of rain. Such conditions are found on certain mountains, as on the Sierra Nevada, for example, where the low temperatures are due to the altitude, or on damp lowlands, as in the vicinity of the lakes, where the climate is continental and therefore the winters are cold. The temperature control over snowfall is clearly indicated in the decrease in the amount of snow towards the south, and also along the Atlantic coast, where, during the winter months, rain frequently falls with onshore winds while it is snowing in the interior, not many miles away.

Over nearly all of the eastern United States the northeast wind, being both cold and damp, is the chief snow-bringer. A "northeast snowstorm" is a familiar winter characteristic, especially along the Atlantic coast.[9] The heaviest snows usually come in February or even in March over the northern sections. The northwest winds, blowing on the rear of the storms, are plenty cold enough to give snow, but are generally too dry. Snow flurries, rather than deep and general snows, are therefore usually associated with them. Exceptions must, however, be made in the case of windward mountain slopes, as in the Appalachian area, and of places to leeward of the Great Lakes, where the northwest winds may bring heavy snowfalls. In an intensive study of two great snowstorms, Dr. Brooks has brought out certain characteristics of snowfall distribution which are doubtless of common occurrence.[10]

Snow fell over a wide area on each side of the storm track. The heaviest snows came with northeast winds, over a belt about 100 to 200 miles in width, to the north of the track. The northwest winds, in the southwest quadrants of the storms, sprinkled light snows over the country as far as about 300 miles to the southward of the track. A distinct "patchiness" in the

[9] Charles F. Brooks, "The Snowfall of the Eastern United States," *Mo. Wea. Rev.*, Vol. 43, 1915, pp. 2–11.

[10] Charles F. Brooks, "The Distribution of Snowfall in Cyclones of the Eastern United States," *Mo. Wea. Rev.*, Vol. 42, 1914, pp. 318–330; Chs. 11.

distribution of these snowfalls resulted from local topographic features.

It is a general characteristic of heavy snowfalls in eastern districts, especially on mountains, that they are accompanied by fairly high winds. A marked contrast to this condition is found in the region of very deep snows on the Sierra Nevada Mountains of California, for example, where the winds are always relatively light.

The greatest 24-hour snowfalls in the different sections of the country have been summarized by Professor Henry as follows: northeast, 2–3 ft.; elsewhere east of the Mississippi River, from 8 inches (Ohio Valley) to 18–20 inches (along the Lower Lakes); southern states, 4–8 inches; Mississippi Valley, 5 inches (Vicksburg) to 20 inches (St. Louis); northern plains, 9–17 inches; Rocky Mountains, 8–24 inches; Plateau and Northern Pacific coast, 10–20 inches.[11]

## General Distribution of Snowfall in the United States

Snow falls regularly every winter over by far the greater part of the United States. The only sections which seem to be exempt from even occasional snowfalls are southern Florida and the lowlands of southernmost California adjacent to the ocean. There is considerable variation in the latitudes which mark the southernmost limits of snowfall in any given winter, but for purposes of convenience and of easy memorizing, the limiting latitudes of regular and of occasional snowfall may be broadly generalized as follows:

Latitudes of Regular and of Occasional Snowfall

| District | Regular | Occasional |
|---|---|---|
| Pacific Coast.. | 45° (northern Oregon) | 34° (Los Angeles) |
| Interior ..... | 30° (northern Gulf) | 26° (southeast Texas) |
| Atlantic Coast.. | 35° (Hatteras) | 29° (northern Gulf) |

From a practical point of view it may be said that snow does not occur in sufficient amount to lie unmelted on the ground south of San Francisco on the lowlands of the Pacific Coast, or south of Cape Hatteras on the Atlantic Coast. This statement, however, does not hold for inland districts, or for elevated areas. The southern boundary of a regular winter snow-cover, in ordinary winters, may be put at about lats. 41°–42° in the eastern United States, but occasional winters carry the snow-cover a good deal farther south. It is one of the marked climatic characteristics of the eastern United States that snow not infre-

[11] *Loc. cit.*, footnote 6, pp. 58–59.

quently occurs unusually far south, in districts which have very mild winters.

The most striking general facts on the snowfall map are the effects of the topography in causing very heavy snowfalls on the western flanks of the Sierra Nevada and Cascade Ranges (exceeding 400 inches over considerable areas); the "snow-shadow" effect of this western mountain barrier in causing a decrease in the depths of snowfall over the interior plateau districts as a whole, with larger amounts over the mountains and higher plateaus; the heavy snows of the Rocky Mountain system, averaging considerably less than on the Pacific Coast mountains, but amounting to more than 100 inches over fairly large areas even as far south as northern New Mexico, reaching over 300 inches in southern Wyoming and 400 inches in parts of the Colorado Rockies. East of the Continental Divide the snowfall rapidly decreases again, the lines of equal depth extending in a general east-and-west direction under the control of latitude. The Appalachian mountains and plateaus carry the lines well to the south (50–100 inches from Maine to Maryland), while the warm waters of the Gulf Stream carry them northward along the coast as far as Cape Hatteras. In the vicinity of the Great Lakes, especially on their lee shores, and thence eastward along the Canadian boundary as far as New England, there is a relatively heavy snowfall (more than 100 inches in northern New England and 80 to more than 100 inches on the lee shores of the lakes). Including the higher altitudes, the annual snowfall may be said to average roughly more than 20 inches over northern and less than 20 inches over southern sections. Most of this snow falls from December to March, but at the higher elevations, and in the northern states, it begins as early as October or even September, and falls as late as April or even May. In general, topography is seen to be the most striking control in the west, and latitude in the east.

## THE SNOWFALL OF THE PACIFIC SLOPE

The snowfall over the lowlands of the Pacific Slope is of little importance. It is very light, even in the north, and seldom excites interest except when, at long intervals, snow falls in southern districts where it is so uncommon as to be a curiosity, or when, occasionally, a heavier fall than usual in the northern districts causes comment. Snow is rare on the immediate coast south of the northern boundary of California (latitude 42° N.), but it is frequent on the mountains, even in southern California.

When snow does occur on the lower lands of southern California, it seems always to fall with hail, sleet or rain.

Interest is, however, naturally very great in what has for years enjoyed the distinction of being the area of heaviest snowfall in the United States. This area, which is clearly indicated on the snowfall map, is on the western slopes of the high Sierras of California, and has been closely studied along the line of the Southern Pacific Railroad which connects Sacramento, Cal., and Reno, Nev. Recent discussions by Professor A. G. McAdie[12] and Andrew H. Palmer[13] have brought out many interesting facts regarding this remarkable snowfall.

Over an elongated area of considerable extent stretching along the windward (western) upper slopes of the mountains, the average annual snowfall is over 400 inches, *i. e.*, over 30 feet deep. Another area, also with over 400 inches, is found over the Cascade Mountains in northern Washington, but has not yet been intensively studied. The average annual snowfall at Summit, Cal. (7,017 ft.), for 44 years, is 419.6 inches, and the average for 8 years at Tamarack (8,000 ft.) is 521.3 inches. During the winter of 1879–80, 783 inches of snow fell at Summit, and in 1889–90, 776 inches. At Tamarack, in 1910–11, 757 inches fell. The depth on the ground (9-year average) has been determined as follows (T, Tamarack; S, Summit):

INCHES

| | Dec. 1 | Jan. 1 | Feb. 1 | Mar. 1 | Mar. 15 | Mar. 31 |
|---|---|---|---|---|---|---|
| T ..... | 19 | 62 | 165 | 183 | 194 | 192 |
| S ..... | 9 | 44 | 122 | 127 | 140 | 118 |

The total precipitation as rain and melted snow is 48.1 inches at Summit and 57.5 inches at Tamarack. These totals by no means represent a very heavy annual precipitation. The significant fact is the proportion of the whole which falls as snow. The Pacific Slope has dry summers and a well-marked winter maximum of precipitation. This maximum results from a combination of various factors, among which the more important are the general winter storms and the prevalence of moisture-laden onshore winds which, in ascending the then cold slopes of the higher mountains, are cooled to temperatures below freezing. This winter maximum is very distinct over the lowlands and valleys, but is less marked at the higher levels. The increase in annual precipitation with increase of altitude, which

[12] See footnote 3.

[13] Andrew H. Palmer, "The Region of Greatest Snowfall in the United States," *Mo. Wea. Rev.*, Vol. 43, 1915, pp. 217–220, with illustrations.

is a general characteristic of mountains, is rapid up to a certain height, after which the rate lessens, and finally there is a decrease in precipitation with altitude. A maximum amount of rainfall, including melted snow, is reached at between 6,000 and 7,000 feet.

Railroad operation in this region shows many responses to the heavy snowfall, as all travellers over the Southern Pacific route, through Summit, well know. The famous "thirty miles of snowsheds" cost $42,000 a mile over single track and $65,000 over double track. About $150,000 is spent annually for upkeep and renewals. The life of a shed averages a little over twenty years. Fire-fighting trains are kept always in readiness in case the sheds take fire, which they often do. The weight of the snow is so great that sections of the sheds occasionally collapse. A heavy rain and snow gauge has been completely crushed by the snow, and a fence made of two-inch boiler flues has been bent. The gables of the houses are all built at sharp angles, so that the snow may slide off. Some very recent observations on Mt. Rainier, Wash., indicate that the snowfall in that district is extraordinarily heavy.[14] Daily records of snowfall were kept during most of the season of 1916–17 at Paradise Inn, on the south slope of Mt. Rainier, at an elevation of 5,500 feet. Observations were not begun until November 24, 1916, but from that date until the last snowstorm before midsummer, 1917, the total depth of snowfall was 789.5 inches. The record at Paradise Inn is the first which has been obtained west of the summit of the Cascades in Washington at so great an elevation. The railroads cross the mountains at comparatively low levels. The season of 1916–17 does not appear to have been one of unusually heavy snowfall, nor is Paradise Inn located at what would theoretically seem to be the region most favorable for a maximum precipitation. It is not unlikely, therefore, that still deeper snows will eventually be recorded at greater altitudes than 5,500 feet on Rainier, which may some day deprive the Sierra Nevada of California of the distinction of having the greatest snowfall in the United States.

The importance of the water-supply from the melting snows of the higher mountains on the Pacific Slope cannot be overestimated. Millions of dollars' worth of water, for irrigation, for power, and for general city and domestic use, are obtained each year from these snows. Without them, most of the valleys and lowlands on the coast would be unable to support their

[14] Lawrence Foster, "Snowfall on Mt. Rainier," *Mo. Wea. Rev.*, Vol. 46, 1918, pp. 327–330.

present crops, and the population of the region would never have attained its present numbers.

### Snowfall over the Western Plateau Region

Over the western plateau area, between the Sierra Nevada-Cascade ranges on the west and the Continental Divide of the Rocky Mountains on the east, most of the winter precipitation comes in the form of snow. The essential features of the snowfall distribution are the general decrease over the valleys and less elevated portions from 20 to 30 inches in the north to less than 5 inches and even to 0 inches in the south. Over these districts of light snowfall the ground usually does not remain covered many days at a time, and in the region of the lower Colorado River, in southwestern Arizona and southeastern California, snow is rarely seen except on the mountains. The mountains and more elevated plateaus have decidedly heavier snows. A maximum of over 400 inches is reached in some parts of Colorado; of 300 inches in southern Wyoming, and of over 100 inches in many places from Idaho and Montana on the north to northern New Mexico on the south. The snowfall in the Colorado mountains is much greater than the summer rainfall, and comes largely in the spring months. Most of the rivers of the plateau states have their sources in the higher mountains, and the slow melting of the snows, which usually last well into the summer, supplies these streams with water which is essential for irrigation. The maximum stream-flow ordinarily comes in late spring or early summer, when the melting of the mountain snows is most rapid. It is a saying among the Indians of Arizona that when the last snow disappears from the mountain tops, the late summer rains are about to begin.

### Snowfall on the Great Plains

Lying to leeward of the Rocky Mountains, and being far from any considerable source of water vapor, the plains inevitably have relatively little snowfall. Their total annual precipitation is less than 20 inches, and most of this falls in summer. Thus winter is a dry season, and the snowfall which it brings is light. Even in the extreme north, where the winters are very cold and practically all the precipitation of the five or six colder months is in the form of snow, the average annual snowfall is under 50 inches. The winter storms do not, as a rule, give much snow. Even the "blizzards" are not usually accompanied by heavy snows. They are dangerous to cattle, and occasionally

to human beings, because of the bitter cold of their northerly winds, and because these same winds carry fine ice spicules and are also filled with blowing snow which makes it difficult or impossible to see. Severe blizzards are, as a matter of fact, not as common as most people think. A whole winter sometimes passes without a typical blizzard.

Over the southern plains, owing to the warmer winters, the snowfall decreases to less than 10 inches, and even to less than 5 inches in western Texas and southern New Mexico. The number of days with snowfall also decreases, from an average of 40 or 50 in the north to 5 or 10 in Oklahoma, and to less than 5 in extreme southwestern Texas.

It is a characteristic of the snowfall over the northern plains that most of it falls at temperatures well below freezing. For this reason it is light and dry, and is easily carried by the strong winds, which blow it into ravines and other depressions, leaving the ranges for the most part bare and accessible for grazing. In the south, the snow soon melts under the warm sun.

Over the mountains which border or interrupt the plains, it snows more frequently and during a longer season. The melting of these deeper snows furnishes much of the water which is used for irrigation along the rivers flowing to the eastward towards the Mississippi.

## Snowfall of the Eastern United States

In the eastern half of the country, the dominant control over snowfall is latitude, as is evidenced by the general east and west trend of the lines of equal depth of snow on the map. Subordinate, but nevertheless important controls are found in the effects of topography (Appalachians, Adirondacks, White Mts. of New Hampshire); of the frequency of cold, damp storm winds (Great Lakes and northeastern sections), and of the warm waters of the Gulf Stream (southern Atlantic coast). The depth of snow decreases to the west of the lakes because winter is there a relatively dry season, and to the south because of the higher temperatures. A detailed study of the snowfall of the eastern United States has been made by Dr. Charles F. Brooks.[15] This shows clearly the local modifications which re-

[15] Charles F. Brooks, "The Snowfall of the Eastern United States," *Mo. Wea. Rev.*, Vol. 43, 1915, pp. 2–11. Includes original charts showing the average depths of snowfall by months, from September to May; the average annual snowfall (1895–1913); the average annual number of days with snowfall; the mean annual, maximum and minimum annual, and extreme annual range of snowfall about the Great Lakes, for the period 1895–1910; also monthly charts showing the directions of the snow-bearing winds.

sult from the topography and from exposure to damp winds. More snow is seen to fall on the western than on the eastern slopes of the Appalachians, except in Vermont.

Over the northern tier of states in the eastern half of the country snow is a factor of considerable economic importance, especially over northeastern sections where the depths are greatest. Sleighing is often possible for weeks at a time in winters of abundant snowfall, the depth of snow on the ground reaching two or three feet in certain sections. Such snows greatly facilitate the lumbering industry by making it possible to use heavy sledges for hauling the logs out of the forests. "Open winters," on the other hand, make lumbering difficult and expensive. Warm winter rains are especially characteristic of the Atlantic coast sections and naturally occur with increasing frequency toward the south, quickly melting any snow which happens to be lying on the ground. In the spring months, heavy rains of this type, or unseasonably high temperatures unaccompanied by rains, not infrequently cause a very rapid melting of the deeper snows lying in the mountains, and produce freshets and floods in the Ohio and other river systems of the northeast.

The season of snowfall over northern sections is a long one. Snow in measurable amounts may fall as early as October, or even in September in the White Mountains of New Hampshire and in the Adirondacks, and as late as May. Indeed, snowstorms of considerable intensity have occurred in April, but the heaviest snowfalls usually come in February, or at times early in March. The general snow-cover advances as a whole from north to south with the advance of winter, very irregularly and often with many retrogressions as well, its southern margin being uneven and broken under the control of varying conditions of topography, storm control and temperature. It usually reaches its southermost limits in January or in February, and then retreats northward again. This seasonal advance and retreat, with its many irregularities, can be studied to advantage on the *Ice and Snow Bulletins* of the Weather Bureau.

Towards the south, as latitudes of milder winters are reached, the season during which snow may fall becomes shorter and shorter. Less and less of the precipitation of the colder months falls as snow, and more and more comes in the form of snow and rain mixed, and then of rain. The number of days with snowfall decreases. Thus, while days with snowfall average over fifty a year over most of the Lake region and St. Lawrence Valley, including northern New England, there is an

average of only one day with snowfall along a line reaching from southeastern North Carolina to south of Vicksburg, Miss. (fifteen years). The mountainous section of all the southern states which are crossed by the Appalachians have more days with snowfall, and more snow than the surrounding lowlands and valleys. There are, for example, fifty days with snowfall a year as far south as Elkins, W. Va., but the accumulation of snow is not sufficiently great to be a factor in causing dangerous spring floods as is the case farther north. With decreasing latitude, snow lies on the ground less and less of the time, and soon becomes an almost, and then an entirely, negligible factor. When it falls over much of the South, it is merely a matter of temporary discomfort, melting soon. Southern South Carolina is practically exempt from snowfall. In Georgia, snow, when it falls, melts almost immediately, although it may remain on the ground a few days in sheltered places in northern sections of the state. It is not an uncommon occurrence for a season to pass without snow enough to cover the ground over the northern portions of the northern gulf coast states. Farther inland, as, *e. g.*, in Tennessee, the ground is rarely covered more than a very few days at a time, but unusually heavy snowstorms, at long intervals, may result in a snow-cover which lasts a week, or even more.

Over the sections immediately adjacent to the Gulf of Mexico, snow becomes practically negligible. Occasionally, at long intervals, there are measurable amounts in northern and even central Florida. The gulf sections of Alabama, Mississippi and Louisiana have a 15-year average of less than one inch, and an average of less than 1 day with snowfall annually. Years may go by without any snow along the Texas coast and in the lower Rio Grande Valley. Much interest attaches to the occasional occurrence of unusual snowfalls in the south. During spells of exceptional cold, snow may fall to the depth of a good many inches at various localities along the southern Atlantic and Gulf coasts, and with diminishing depth even as far as extreme southeastern Texas. On such occasions, thousands of people witness their first snowstorm.

## Sleet and Ice Storms

Sleet and ice storms are so closely associated with snowstorms in the eastern United States that it is often difficult to forecast snow because a storm of sleet or ice may occur instead. According to the present Weather Bureau definition, sleet is precipitation that occurs in the form of frozen or partly frozen

rain. It is formed by rain falling through a relatively warm stratum into or through another stratum which is cold enough to freeze some or all of the rain drops. When, under these general conditions, rain drops fall to the earth's surface and freeze on coming in contact with solid objects on that surface, an ice-storm results. Telegraph, telephone and trolley wires, trees, sidewalks and streets are then covered with an icy coating. Service is thus often interrupted because of broken wires, and transportation becomes difficult or dangerous by reason of slippery rails and streets. Considerable damage is often done to forest and fruit trees by such ice-storms. Mr. Verne Rhoades, of the U. S. Forest Service, has called attention to the widespread damage caused by a single ice-storm in the southern Appalachians,[16] and Mr. W. W. Ashe, Forest Inspector of the Forest Service, has pointed out that the damage done by these storms is such that the dates of past ice-storms may be determined by an examination of the trees. In the case of trees damaged by a recent ice-storm along the Blue Ridge Mts., in Amherst Co., Va., evidence was found of injury by two previous storms, about 14 and 35 years, respectively, before the last one.[17] Professor H. C. Frankenfield, of the Weather Bureau, has recently made a study of sleet and ice storms in the United States.[18]

The region of maximum frequency is over a broad central belt reaching from west of the Mississippi eastward and northeastward to the Atlantic. This is, in general, the portion of the country which is crossed by the principal storm areas, with their cold northerly winds to the north and warm southerly winds on the south of their centers. These conditions are essential to sleet formation. Severe sleet storms may occur from November to March, inclusive, and occasionally in April and October to the north of the 42d parallel. It appears that steep northward temperature gradients, and high temperatures over the Gulf and South Atlantic States are necessary for sleet formation, and are usually absent before and during heavy snows. Surface temperatures preceding sleet and ice storms are below freezing, usually between 22° and 28°, and the high

[16] Verne Rhoades, "Ice Storms in the Southern Appalachians," *Mo. Wea. Rev.*, Vol. 46, 1918, pp. 373–374.

[18] H. C. Frankenfield, "Sleet and Ice Storms in the United States," *Proc. 2d Pan. Amer. Sci. Congr.*, Vol. 2, Section 2; Astronomy, Meteorology, and Seismology, pp. 249–257 (discussion, pp. 252–257). Washington, D. C., 1917. (Gives a map showing the average annual frequency of sleet and ice storms, and typical weather maps favorable for their occurrence.)

[17] *Ibid.*

temperatures in the south which precede the sleet are accompanied by southeasterly to southerly winds.

The ice-storms of New England have been discussed in some detail by Brooks,[19] who has based his study chiefly on the very complete records obtained at Blue Hill Observatory, Mass., and has included a consideration of upper-air conditions. Three general types of wind conditions produce ice-storms. These are (1) warm air arriving over residual cold air ("southerly" type); (2) cold air coming in below and warm air arriving above ("northeasterly" type); (3) cold air pushing in from the north or west below a rain cloud ("northwesterly" type). Classifying ice-storms according to the positions and movements of the low and high pressure conditions (cyclones and anticyclones) which produced them, there are seen to be two large groups. The first includes storms with anticyclones in the north dominating southern cyclones, and the second includes those in which the cyclones and anticyclones were in regular sequence.

## Is Snowfall Decreasing?

There is a widespread popular belief in many parts of the country, especially in the earlier settled sections of the northeast, that less snow falls now than was the case years ago. In New England, for example, it is customary to speak of the "old-fashioned New England winters" which brought many heavy snowstorms; when snow lay on the ground uninterruptedly all winter, and when sleighing was possible for three or four months without a break. In a question of this kind it is, of course, impossible, to put any confidence in general impressions or in tradition. It is a mistake to place absolute trust in our memories, and attempt to judge such subtle things as differences in snowfall on the basis of such memories, which are at best short, defective, and in the highest degree untrustworthy. The tendency inevitably is to exaggerate past events; to remember a few exceptional seasons which, for one reason or another, made a deep impression on us, and very much to overrate some special event. Individual severe winters which, as they occur, are some years apart, seem, when looked back upon from a distance of several years later, to have been close together. It is much as in the case of the telegraph poles along a railroad track. When we are near the individual poles, they seem fairly far

[19] Charles F. Brooks, "The Ice Storms of New England," *Annals Astron. Obsy. Harv. Coll.*, Vol. 73, Pt. 1, 4to, Cambridge, Mass., 1914, pp. 8, pls. 2 (Abstract in *Mo. Wea. Rev.*, Vol. 42, 1914, pp. 455–457); "Three Ice Storms," *Science*, Aug. 8, 1913, pp. 193–194.

apart, but when we look down the track, the poles seem to stand close together. The difference in the impressions upon youthful and adult minds may account for part of this popular belief in changes of climate. To a youthful mind a heavy snowstorm is a memorable thing. It makes a deep impression, which lasts long and which, in later years, when snowstorms are just as heavy, seems to dwarf the recent storms in comparison with the older.

Changes of residence may account for some of the prevailing ideas about changes of climate. One who was brought up as a child in the country, where snow drifts deep and where roads are not quickly broken out, and who later removes to a city, where the temperatures are slightly higher, where the houses are warmer, and where the snow is quickly removed from the streets, naturally thinks that the winters are milder or less snowy than when he was a child.

The only reliable evidence is that which rests upon instrumental records. Accurate instruments, properly exposed and carefully read, do not lie; do not forget; are not prejudiced. When such instrumental records, scattered though they are, and difficult as it is to draw general conclusions from them, are carefully examined, from the time when they were first kept in this country, which in a few cases goes back a century or more, there is found no evidence of any progressive change in the amount of snowfall. Some winters now bring deeper snows and greater cold, while others are mild and "open." These variations result from differences in the numbers, intensity and paths of winter storms, as is clearly seen by a study of the daily weather maps. This same sort of variability was characteristic of the past, and will continue forever. In other words, a mild winter with light snowfall is just as "old-fashioned" as one with severe cold and heavy snowfall. There were plenty of both kinds of winters in the past. There will be plenty of both kinds in the future.

In his "Climatology of the United States," which was a standard publication in its day (1857), Lorin Blodget, in a chapter on the "Permanence of the Principal Conditions of Climate," speaking of the evidence for and against climatic change, held that "real history would be more valuable than anything else if it could be relied on, but there is great looseness with much exaggeration in everything dating back beyond the use of instruments." Blodget believed that "the Northmen found the New England coast 860 years ago quite precisely the

same in climate as now—wild vines growing in a very few of the most favored spots, and only in these."

Dr. Hugh Williamson is quoted as saying, in 1770, that the winters of the last half-century had been milder than formerly, and Professor Samuel Williams, of Harvard College, whose lectures were among the foundation-stones of American meteorology, asserted that "the winter is less severe, cold weather does not come on so soon." These views sound singularly like those which are heard expressed nowadays. It so happens that the early settlers of New England made a special point of keeping a chronicle of weather conditions, so that we have a record of the character of the seasons running back over three centuries. When these old accounts are examined, it at once becomes apparent that New England had precisely the same variability in its winters in the earlier days of its settlement as now. There are accounts of great cold; of deep snows; of violent winter storms. There are also many descriptions of very mild and open winters. Thus, we read of December and January resembling May and June; of flowers growing in the woods in midwinter; of so little snowfall "as scarcely to give opportunity for enjoying the music of the sleigh-bells"; of "green Christmases"; of "winter turned into summer"; of the "ground bare for the most part"; of little ice; of crocuses up, of wild violets in bloom, and of lilacs "throwing out their leaves" in January.

It has been well pointed out that if a list were compiled of heavy snowstorms, of droughts, of floods, of severe cold, of mild winters, of heavy rains, and of other similar meteorological phenomena, for one of the early-settled portions of the United States, beginning with the date of the first white settlements and extending down to the present day, we should have the following situation. Dividing this list into halves, each division containing the same number of years, it would be found, speaking in general terms, that for every mild winter in the first half there would be a mild winter in the second; for every long-continued drought in the first division there would be a similar drought in the second; for every "old-fashioned" winter in the first group there would be an "old-fashioned" winter in the second. And so on, through the list. In other words, weather and climate have not changed from the time of the landing of the Pilgrims down to the present day.

# THE ORIGINS OF CIVILIZATION—II

By Professor JAMES HENRY BREASTED

THE UNIVERSITY OF CHICAGO

THE evidence for the possession of domestic animals is not as old as that for agriculture. The bodies from the earliest Egyptian cemeteries contain fragments of bones of mammals, but there is no way to prove that these necessarily small fragments belonged to *domesticated* mammals. Nevertheless, the results of long continued selective breeding demonstrate the remote origin of domestic animals in the Nile valley. At the same time the monuments reveal the Egyptians as persistently practising domestication far down in the historic age.

Pre-dynastic reliefs (Fig. 24) to be dated not later than the middle of the fourth millennium B.C., already show us three of the commonest domestic animals, the donkey, sheep and cattle. The domesticated donkey of Egypt was long ago demonstrated by Schweinfurth and others to have had its original home in northeast Africa and to have been domesticated on the Nile. Its wild ancestor, *Asinus tæniopus*, or the steppe ass, is still found as far north as the mountains of southern Nubia.[18]

The sheep shown in this carving still display primitive characteristics, carried over into the domesticated state, *e. g.*, standing ears and a mane, and the female with horns, which she later lost. They have been identified as *Ovis longipes palæoægypticus* by Duerst and Gaillard. Their nearest relatives, as both these two scientists admit, are still scattered over north and northeast Africa to-day. It is the more remarkable that these two paleontologists would draw this sheep from Asia. Lortet, on the basis of far more material, states that this sheep (*Ovis longipes pal.*) with transverse horns, spirally twisted, has so many and so widely distributed relatives in north Africa, that he must be considered as indigenous there.[19]

Regarding the large cattle shown here the paleontologists have differed widely, with perhaps a majority maintaining his Asiatic origin, due to the fact that they were unable to find an unmistakable wild ancestor in Africa. His alleged Asiatic origin has been commonly asserted in popular books, coupled with such a remote date for his domestication, and his intro-

[18] Schweinfurth, *Zeitschr. f. Ethn.*, 44, 1912, pp. 653–654.

[19] Lortet-Gaillard, "La Faune Momifiée de l'ancienne Egypte," Lyons, 1905, p. 100.

duction into Egypt by some mysterious and unidentifiable immigrants alleged to have brought in Egyptian civilization from Asia, that we now find a widely circulating popular statement, to the effect that the Asiatic origin of Egyptian domestic animals has demonstrated the Asiatic origin of Egyptian civilization.

Both the monuments and the still largely unexplored Pleistocene strata of Egypt contain much evidence on this question.

FIG. 24. EGYPTIAN RELIEF CARVED IN SLATE, DATING ABOUT THE MIDDLE OF THE FOURTH MILLENNIUM, B.C. Showing domesticated sheep (below), donkeys (middle), and cattle (above), captured from the Libyans. Now in the National Museum at Cairo.

It quickly disposes of the Asiatic origin of these long-horned cattle. Much inscriptional evidence has shown that the Egyptians practised the hunting of wild cattle, but a relief in Benihasan which shows these cattle as spotted has led to the conclusion that such alleged wild cattle were really domestic breeds which had escaped from captivity and were running wild. The discovery of a relief of the Pyramid Age showing a hunting enclosure (Fig. 25) filled with game to be brought down by the royal arrows, has effectually disposed of this conclusion. Among the game entrapped in the enclosure we find a cow, a

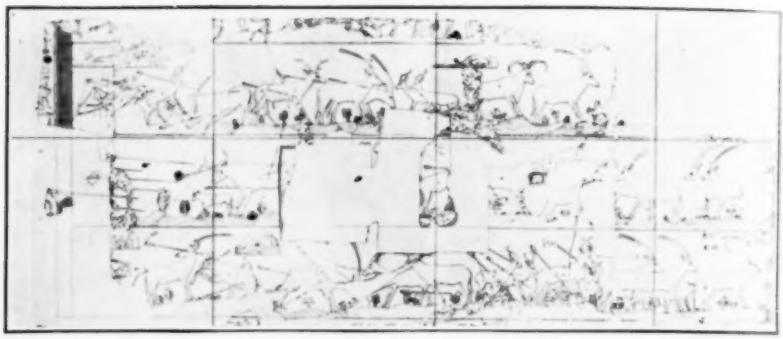


FIG. 25. ANCIENT EGYPTIAN RELIEF SHOWING A ROYAL HUNTING ENCLOSURE FILLED WITH WOUNDED ANIMALS. From the pyramid temple of Sahure, middle of the 28th century B.C. (After Borchardt.)

calf and a bull, all of a red brown color with a lighter saddle. These are unquestionably long-horned wild cattle, identified by Hilzheimer as *Bos africanus*. Pleistocene wild cattle have been proven to have existed in Algiers, and this evidence is now supplemented by the discovery of the fragment of a head of *Bos primigenius* in the Nile valley, in the Pleistocene deposits of the Fayum. The presence of the Urus thus demonstrated in Egypt has led Hilzheimer to recognize the wild cattle in this hunting scene also as the *Bos primigenius*. In any case it is totally gratuitous to identify any longer the long-horned cattle of Egypt with an Asiatic species.

It is very instructive in this connection to notice that the Egyptian continued his efforts at domestication on a wide range of wild creatures, far down into the historic epoch. In the scene under discussion (Fig. 25), dating from the middle of the twenty-eighth century B.C., we see the enclosure, which has been well said to be of itself a long step toward domestication. Here have been caught the deer, the gazelle, the oryx, the addax, and two varieties of goat. Of the leading Egyptian antilopes only the ibex is lacking. The practice of capturing these animals in an enclosure evidently very early showed the Egyptian that he might in this way maintain a store of meat on the hoof from which he could conveniently draw at will. In this way, for example, the Tschuktchi of northeast Asia maintain herds of half-domesticated reindeer, which they employ only as sources of flesh and skin clothing. These wild creatures taken out of such enclosures alive were then stall-fed and partially if not wholly domesticated. We see them in the tomb reliefs between 3000 and 2500 B.C. (*e. g.*, Fig. 26), along with the long-horned *Bos africanus*, tied to their mangers and feeding. Here are the goat (*Hircus mambrinus*), the gazelle (*Ga*

*zella dorcas*), the addax (*Addax nasomaculata*), the oryx (*Oryx leucoryx*) and remarkably enough, the hyena (*Hyæna striata*).

The inscriptions confirm these relief pictures very conclusively. A mortuary text of the Middle Kingdom (around 2000 B.C.) mentions "ibexes which eat grain." Similarly already in the twenty-seventh century B.C., the tomb of Kegemni mentions "stables of the plateau antilopes" (Fig. 27). There were thus "stables" for these creatures, parallel with the stables for the large cattle, and designated by the same word. It is of course a scene from one of these stables which shows these animals eating at their mangers (Fig. 26).

These animals therefore formed a staple source of the food supply and we find them in process of being slaughtered for food, precisely as is done with the large cattle (Fig. 28). Hence at an inspection of the cattle of an estate, these creatures which we have never thought of as domesticated, duly appear together with the long-horn cattle familiar to us as domestic animals (Fig. 29).

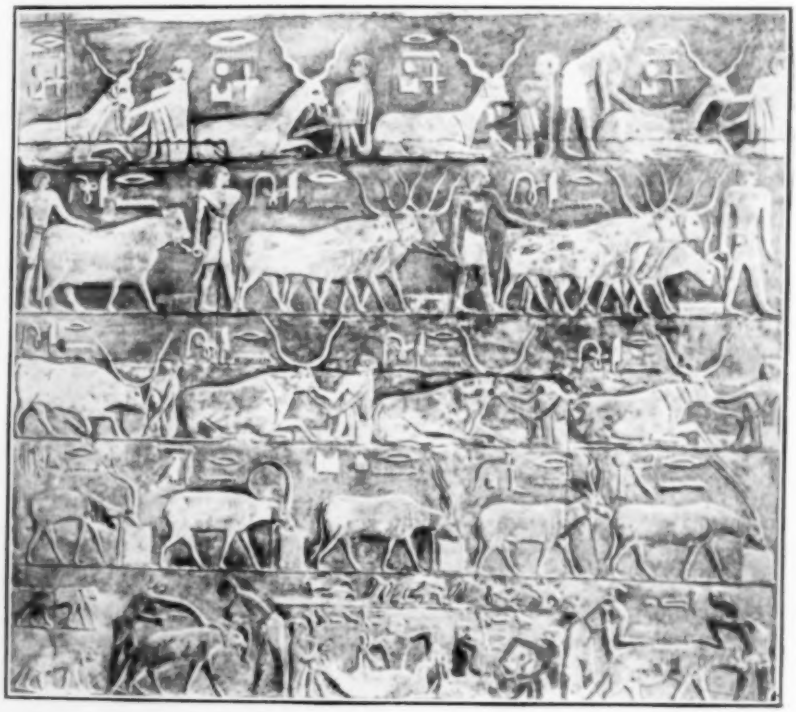


FIG. 26. STALL FEEDING OF SEMI-DOMESTICATED ANTILOPES (FIVE VARIETIES) AND HYENAS, ALONG WITH CATTLE. Relief scene in the tomb of Mereruka at Sakkara, Egypt, 27th century B.C.

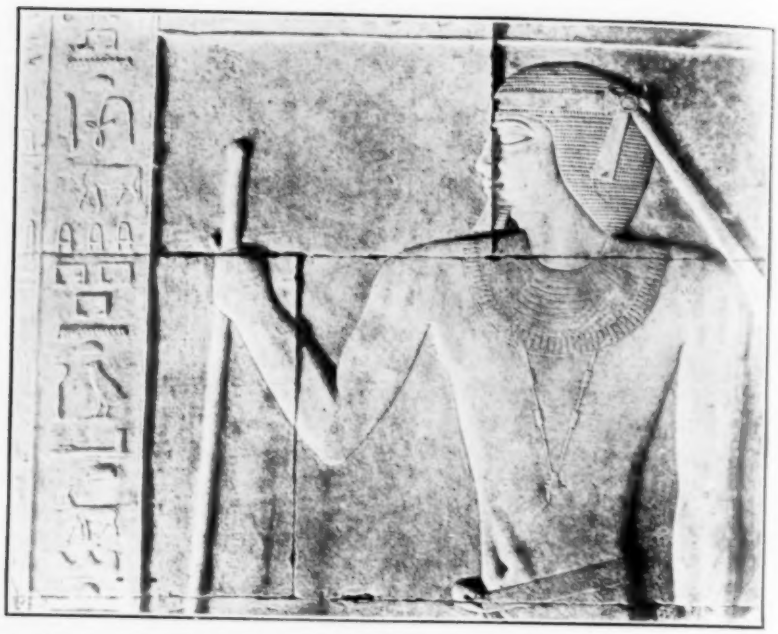


FIG. 27. PORTRAIT OF A GREAT LORD OF THE PYRAMID AGE NAMED KEGEMNI. Accompanied by his titles as "Chief of the Stables of Cattle and Chief of the Stables of the Plateau Antilopes." Relief in his tomb at Sakkara, Egypt, 26th or 27th century B.C.

In the same way, after domesticating varieties of the goose and duck, the Egyptians captured a varied list of wild fowl which they wholly or partially domesticated, although this list did not include our barnyard fowl, which was introduced in the west from India from the seventh century B.C. onward. It will be seen, then, how widely extended and inclusive was the effort of the Egyptians at domestication. They were still continuing the task in historic times, and it went on throughout the third millennium, if not much later.

It is evident from the conditions among their domestic cattle, furthermore, that they had long been engaged in the process of

FIG. 28. BUTCHERING OF SEMI-DOMESTICATED ANTILOPES, SHOWN IN THE TOMB OF KEGEMNI. Compare Fig. 29.

FIG. 29. CATTLE INSPECTION INCLUDING SEMI-DOMESTICATED ANTILOPES ALONG WITH DOMESTICATED CATTLE. As shown in reliefs from the tomb of Manofer, now in the Berlin Museum (27th century B.C.).

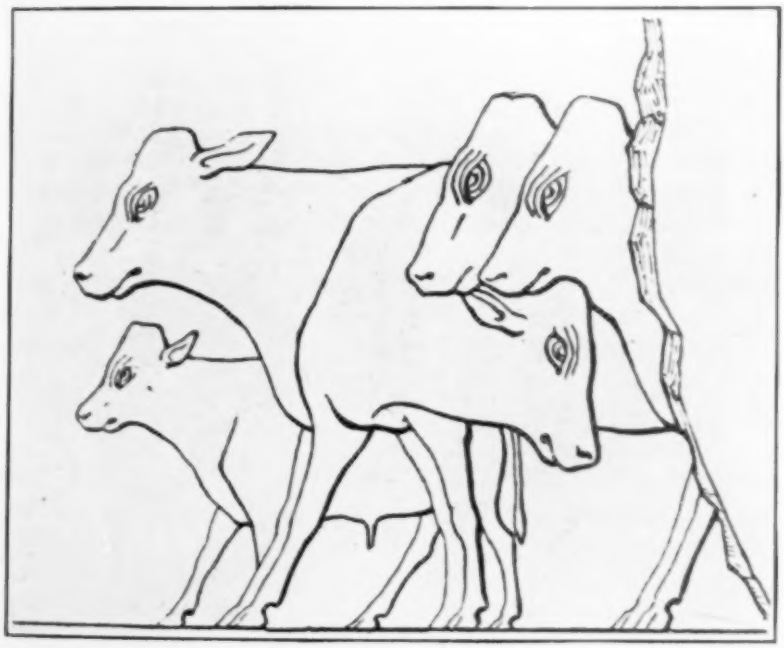


FIG. 30. HORNLESS BREED OF EGYPTIAN CATTLE. From a tomb relief at Gizeh, 29th century B.C.

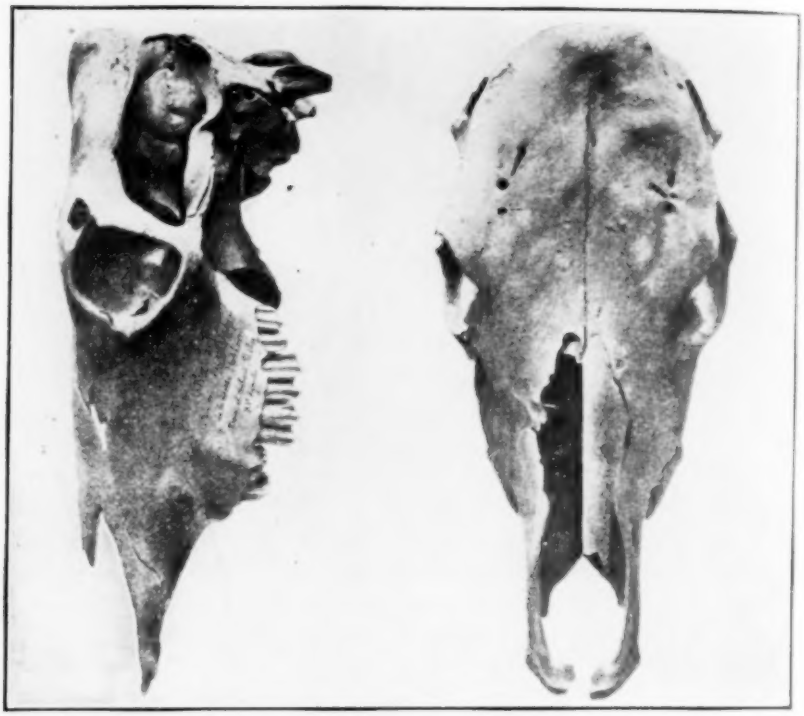


FIG. 31. SKULL OF A HORNLESS BREED OF ANCIENT EGYPTIAN CATTLE. Taken from an XIth Dynasty tomb (2160–2000 B.C.). (After Lortet and Gaillard, "Faune momifiée.")

breeding. For not only had they early developed a short-horn variety out of the long-horn, which was not identical with the Asiatic short-horn (*Bos brachyceros*), but at the same time they also bred a hornless variety of cattle (Fig. 30) (*Bos akeratos*). The actual skulls of this hornless breed have survived (Fig. 31).

A series examined by Lortet led him, like Duerst, to conclude that this hornless breed of cattle was the result of long and persistent selective breeding, very intelligently carried on. In this case we would have here a situation like that which we found in the case of the domesticated grains. Wheat with ages of selective cultivation behind it, has been found in the earliest known graves in the world. Similarly the oldest domesticated herds known to modern science, that is the oldest cattle in the world, would, according to Lortet and Duerst, already include a hornless breed produced by long-continued selective propagation.

On the other hand Professor Charles B. Davenport, director of the Department of Experimental Evolution of the Carnegie Institution, has kindly informed me that "hornlessness in cattle has probably arisen many times as a sport or mutation," and might then be continued and perpetuated by selective breeding. He concludes that the hornless breed of ancient Egypt arose and was continued in this way. In either case intelligently practised cattle-breeding on the part of the Nile dwellers at a very early date is evident.

We can understand therefore, that the production of milk-producing cattle was the result of long-continued and intelligently directed selective breeding, already completed by 3000 B.C. That the milk breed had not yet become wholly accustomed to the artificial abstraction of milk by the hand of man is evident from the fact that in practically all such dairy scenes, the hind legs of the cow have been elaborately tied (Fig. 32). It is perhaps of importance to note also that the calf is kept in the vicinity, and its eagerness for maternal food is restrained by another herdsman while the milking process goes on.

It is thus evident that conditions both in agriculture and cattle breeding in the Nile valley at the earliest stage when they are observable by us, point clearly back to a long antecedent development, beginning far away in the remote ages when the Nile dwellers lived on the lower alluvium, where the remains of their life are still buried.

The domestication of cattle, like that of donkeys, reacted powerfully on agriculture, as it was gradually discerned that the hoe might be replaced by the ox-drawn plow. Nothing shows more clearly the evolution of Egyptian civilization as a Nile valley process, than the unnoticed fact that the plow drawn

FIG. 32. EGYPTIAN HERDSMEN MILKING. Relief scene in the tomb of Ti at Sakkara, 28th century B.C.

FIG. 33. EGYPTIAN PEASANTS PLOWING. From a tomb relief of the 26th–27th century B.C., now in the Louvre in Paris.

by oxen is simply the old prehistoric wooden hoe equipped with necessary modifications. The primitive form of the Egyptian plow is twice shown in the right-hand column of hieroglyphs in the plowing scene in Fig. 33. Now it can be demonstrated that Egyptian writing has preserved for us pictures of primitive and archaic forms of every day implements, which survived thus in the writing long after they had been displaced by improved forms and hence had ceased to be used in real life. Thus the inscription behind the plowman (Fig. 33) twice displays for us a tiny picture of a form of plow enormously older than the one here shown in actual use. It will be seen that the beam of the plow (in the inscription) is very short, and that the handles are almost too small for use. Indeed this oldest form of the Egyptian plow is little more than the hoe out of which it has developed.

The wooden hoe of the Egyptian peasant (Fig. 34) was made up of two pieces: one, the handle, abnormally short; the other, the blade, disproportionately long. With the exception of the tiny handles shown in the archaic plow just examined in the writing, this hoe is identical with the plow.

An old Egyptian drawing of a plow of about 2000 B.C. (Fig. 34) exhibits clearly the origin of the implement. The handle (of the hoe) has been lengthened to become the beam (of the plow) while the handles for the plowman's use have been sec-

ondarily attached at the point of junction of beam and hoe-blade or plow-share. The builder really constructed a wooden hoe with somewhat elongated handle as plow beam, and then afterward attached the plow handles, which do not engage with the beam or the plowshare, as they would do if they were of one construction with them.

These facts make it certain that the evolution of plow culture from hoe culture took place *in the Nile valley*. Indeed we are here tracing in the gradually developing material basis of life, a process which bears the stamp of the Nile valley, and is unmistakably Nilotic throughout its course.

Here then, so far as we can see, for the first time in the career of man, and at only one point in the fringe of hunting life which encircled the whole Mediterranean, there grew up at its southeast corner (Fig. 2) far back in the fifth millennium before Christ, a community of Stone Age men who had gradually shifted from the hunting life to that of herdsmen and shepherds, plowmen and cultivators of the soil. While it may have required over six thousand acres to support a hunter and his family, a very few acres would maintain the grain-raising, cattle-raising Stone Age family, and the population must have greatly increased in numbers and in density. Such a body of population following the agricultural and cattle-breeding life at the southeast corner of the Mediterranean must inevitably have exerted an influence on surrounding populations. Such a diffusion as that which carried Central American culture traits

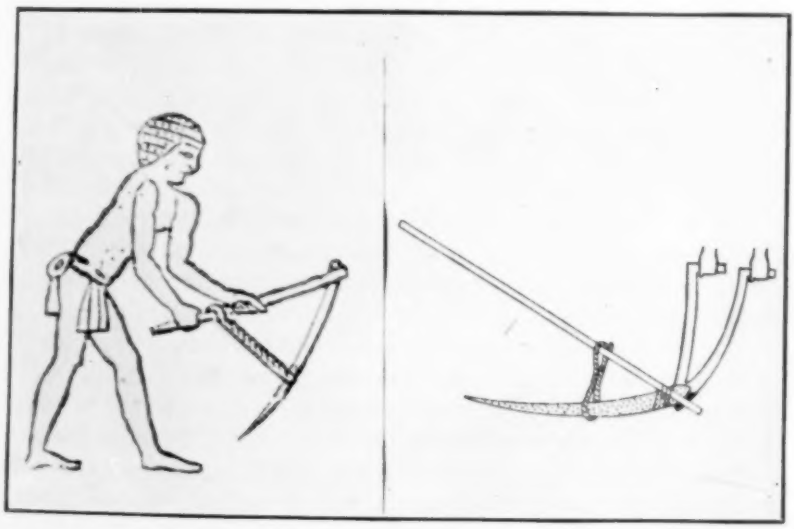


FIG. 34. AN EGYPTIAN WOODEN HOE AND THE WOODEN PLOW WHICH GREW OUT OF IT.

northward and southward until they penetrated far across both North and South America must inevitably have taken place. As to Europe this diffusion was all the easier, because the elevation of the land which made England a part of the neighboring continent, and joined Europe likewise to the mainland of Africa through Italy and Spain—this elevation continued far down into the Neolithic Age, and these land bridges must have been available long after the advances of Egypt just discussed were accomplished (Fig. 2). The same road by which the great African mammals migrated from Africa to Europe was unquestionably still open when the Nile dwellers first began to cultivate fields of grain and breed herds of cattle. It is no accident that the earliest grains of the Swiss Lake Dwellers were barley, emmer and millet, just as in the Nile valley. We have only to look at the dissemination of maize culture in North America from a Central American center to see how easy and inevitable such dispersion is. Moreover, we can actually trace cattle for some distance on the road from Egypt to Europe.

As far back as the middle of the fourth millennium B.C. the Libyans are shown by the Egyptian monuments to have possessed domesticated cattle, sheep and asses (Fig. 24). Such livestock plunder captured by the Egyptians from the Libyans is found in later reliefs also (Fig. 35), which show us large cattle, donkeys, sheep and goats in the possession of a people whose territory stretched far westward along the northern coast of Africa toward Tunis and the region opposite Italy. Thus in remote prehistoric times, Stone Age Europe so long retarded by the ice and cold, began to profit by the progress of the more favored and hence more advanced region at the southeast corner of the Mediterranean. The Neolithic peoples of southern and central Europe were thus able to make the transition from the hunting life, to that of settled communities following agriculture and cattle-breeding. This Neolithic life of Europe, preserved to us especially in the Lake Villages of Switzerland and the *terramare* settlements of the Po valley, was unable to advance by itself to the conquest of metal and the invention of writing, and thus to gain civilization. While interesting, it is of minor importance for the theme of these lectures. Entirely dependent upon the eastern Mediterranean, this Neolithic culture of the West never swung into the current of civilized life until after Greek and Phœnician colonization, and finally Roman conquest gradually civilized it. Its chief importance for our theme is its illustration of the earliest great contribution of the Orient to Europe, as cattle and domesticated grain found their

way across the Mediterranean. The position of this contribution in the long continued westward drift of culture will be found suggested later in Fig. 134.

It now seems to be exceedingly probable, if not a demonstrated fact also, that the south and west European communi-

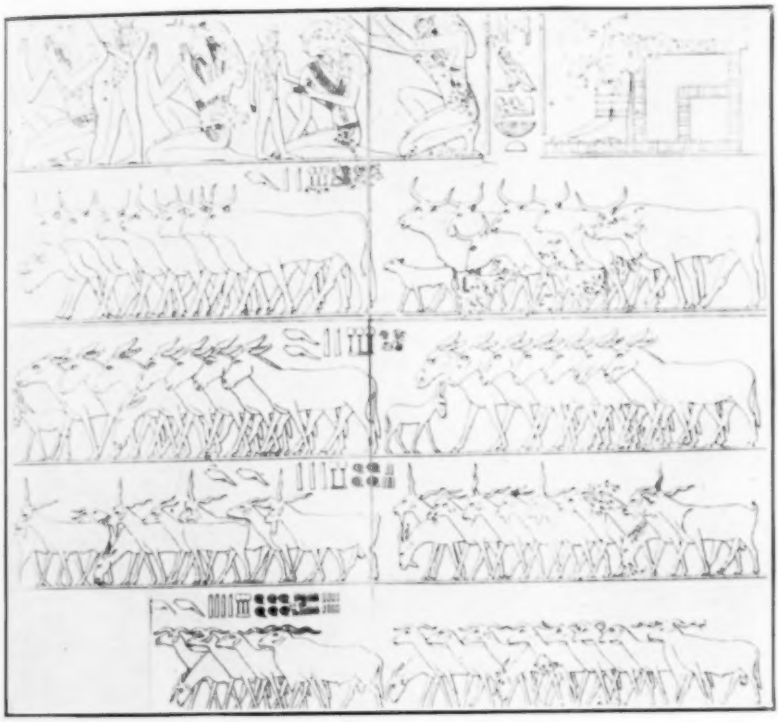


FIG. 35. DOMESTIC ANIMALS OF THE LIBYANS CAPTURED BY THE EGYPTIANS. (28th century B.C.) Compare also Fig. 24. (After Borchardt.)

ties who inaugurated the Neolithic culture of Europe, were of the same race as the prehistoric peoples on the south side of the Mediterranean, or at least as these Egyptians whom we find in the earliest cemeteries. Giving all due consideration to the wide divergence of opinion among the physical anthropologists, it would seem that the studies of Elliot Smith among the largest series of prehistoric Egyptian bodies yet investigated, have demonstrated clearly the identity or close affinity between these prehistoric Egyptians and the south Europeans of the great peninsulas, called by Sergi the Mediterranean race. As Smith has shown in a restoration of a profile from an early predynastic skull (Fig. 36), and as we see also in a late pre-

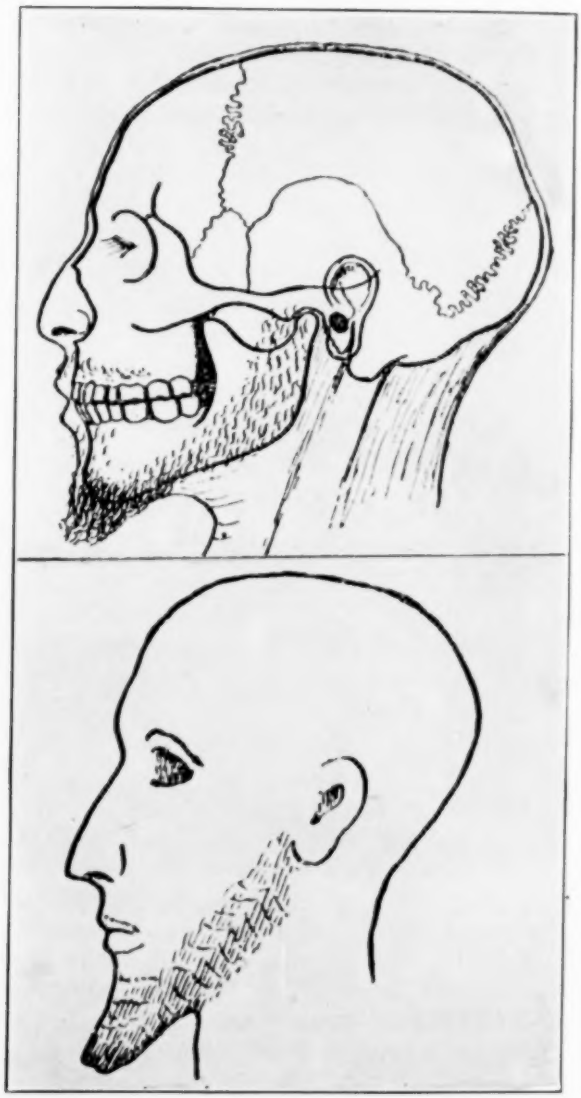


FIG. 36. PROFILE OF A PRE-HISTORIC EGYPTIAN (ABOVE) RESTORED FROM AN EARLY PRE-DYNASTIC SKULL BY DR. ELLIOT SMITH, AND HEAD OF A LATE PRE-DYNASTIC STATUETTE. (The latter after Quibell, "Hierakonpolis.")

dynastic statuette, the prehistoric Egyptians were a narrow-headed, long-faced, dark-haired, and almost certainly dark-eyed race. They were rather low in stature (the men a little under 5 feet 5 inches; the women almost 5 feet), and they were of slender build. They were not negro or negroid, and their kin are to be found in Europe, rather than in Africa.

It must have been after a very long career as a settled agricultural and cattle-raising people, that these dwellers on the Nile alluvium discovered and began to use metal. Unlike the domestication of grain and cattle, the introduction of metal was hardly earlier than the dawn of civilization. We can therefore trace the incoming of metal as we cannot follow the rise of agriculture and cattle-breeding. The graves of our early cemeteries (Fig. 22) disclose to us not merely cultivated grain and domestic cattle, but also metal. For in the very earliest of the predynastic graves we find copper needles with the eye produced by bending the butt around in a hook-eye (Fig. 37). Copper beads and bracelets also show that the earliest use of the metal was chiefly for ornaments. These needles are the earliest implements of metal smelted and wrought by man; for they carry this primitive and limited use of the metal back into the fifth millennium B.C., that is back of 4000 B.C. Man thus began to smelt and use metal about six thousand years ago.

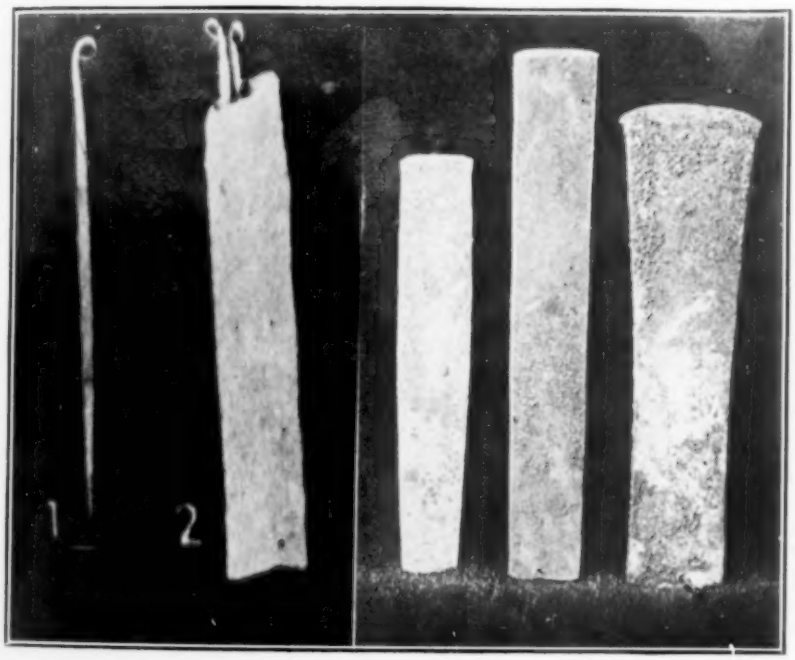



FIG. 37. COPPER NEEDLES WITH HOOK-EYES, THE EARLIEST KNOWN IMPLEMENTS OF METAL. Such needles are found in Egyptian graves dating before 4000 B.C. (After Reisner.)

FIG. 38. THE EARLIEST KNOWN METAL TOOLS: CHISELS OF COPPER FOUND IN PREDYNASTIC EGYPTIAN GRAVES ABOUT 35TH CENTURY B.C. (Photo by Petrie.)

Gradually the Nile-dwellers learned that the metal which they were using for ornaments might be made into tools and weapons, giving them a new power over men and nature. With tools and weapons like these (Fig. 38), which appear in the late pre-dynastic graves by the middle of the fourth millennium B.C., when all the world was elsewhere using only stone implements and weapons, the life of man entered upon a new epoch and at the southeastern corner of the Mediterranean a mechanically gifted people began to respond rapidly to the possession of this new source of power. This response of an ingenious people to the possession of metal culminated in the emergence of a united nation, the first great social and administrative structure erected by man, whose organized capacity was, half a millennium later, to be expressed in monumental form in the pyramids of Gizeh.

The process of political unification which went on among the prehistoric petty kingdoms and chieftaincies distributed along the Nile, is only dimly discernible in the scanty monuments surviving from this remote age. We see these early leaders bearing pointed metal weapons in the hunt, for the Nile-dwellers continued their old hunting habits for thousands of years after the rise of civilization. Monuments from the middle of the fourth millennium show us the Nile chieftains still following the chase (Fig. 39). But even such a document as this hunting scene (Fig. 39) also clearly discloses something of the vast social and governmental progress made by the earliest men, a progress which had carried them away from reliance on the chase, toward the possession of a stable food

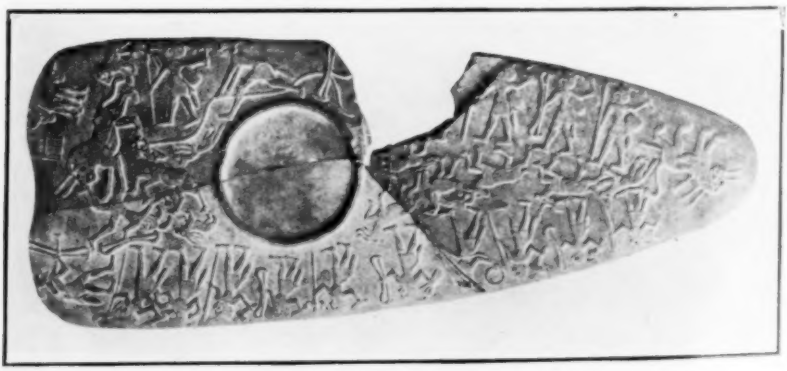


FIG. 39. NILE CHIEFTAINS OF THE MIDDLE OF THE FOURTH MILLENNIUM B.C. ENGAGED IN HUNTING. Depicted in a relief on a slate palette used for grinding face paint. (After Legge in *Proceedings of the Society of Biblical Archæology*, Vol. XXIX.)

FIG. 40. A ROYAL DIGGING CEREMONY OF EARLY DYNASTIC AGE DEPICTED IN A RELIEF ON A CEREMONIAL MACE-HEAD. (From Quibell, "Hierakonpolis.")

supply available to large communities abiding in fixed dwelling places. These hunting chieftains carry standards on which are mounted symbols signifying political divisions—the earliest such symbols known. We recognize in them prehistoric forms some of which are well known to us in later hieroglyphic signs. Thus the fifth hunter in the upper line carries a symbol mean-

ing "the East" in the hieroglyphic of half a millennium later. Each hunter also wears attached to his girdle behind, the tail of a wild animal—a symbol retained in historic times only by the Pharaoh.

One of the most powerful influences toward unity and organized development in a rainless climate like that of Egypt, was the necessity of creating an ever more complicated irrigation system. To maintain such a system, to keep each of its long canals free from obstruction, and to control the supply of water, required the cooperation of large groups of communities, created a consciousness of community of interest and a willingness to submit to a central authority in control of the whole. One of the ancient prehistoric rulers shown in Fig. 40 beside a canal wielding an archaic wooden hoe, is evidently engaged in ceremonially digging up the earth, for which his attendant holds a basket. Such a ceremonial act may well have marked the beginning or dedication of some irrigation canal. Thus the possession of grain fields, and the maintenance of herds which must be pastured, bound great groups of communities to a common system for the support of the whole, which could never have grown up among the hunting chieftains of earlier days.

By the middle of the forty-third century B.C., this system had brought forth a calendar of twelve thirty-day months, and five feast days at the end of the year. This is the calendar which has descended to us through the Romans, though it should be observed that the Egyptian rulers were far too practical to make a calendar which would oblige their people to learn a verse of poetry in order to find out how many days there were in a given month.

*(To be continued)*

# THE MEANING FOR HUMANITY OF THE AERIAL CROSSING OF THE OCEAN

By Dr. GEORGE de BOTHEZAT

AERODYNAMICAL EXPERT, NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

THE recent great achievements of the American and British aircrafts show in a striking manner that we are on the eve of the establishment of regular transoceanic aerial voyages. How many centuries, first of audacious dreams, afterwards of daring efforts, were necessary, before this magnificent and powerful realization!

Transoceanic aerial flight is such a powerful factor in humanity's progress and evolution that I fear the language used to-day by human beings is scarcely adequate to describe the magnificent destiny it will produce. This is why I ask indulgence for the audacity of this attempt to analyze the significance of this majestic achievement.

In the aurora of the centuries taken for the blossoming of humanity on our sorrowful planet, the evolution of man started very slowly. Left to himself, with only his physical forces to lead him towards an unknown destiny, of whose greatness, however, he had an unconscious feeling, man would have succumbed under the superiority of innumerable adversaries and adversities, if it had not been for the gleam of consciousness that was smouldering within him. It is the omnipotence of this consciousness that has subdued the universe to man and has made him its uncontested master. It is this consciousness that caused the majestic process of biological evolution to take a new form. The adaptation of the species to outside conditions was transformed into the adaptation of outside conditions to the species, and it is this modification of the biological path that marks the origin of humanity.

The first steps were exceedingly slow and laborious. The first conquests of prehistoric civilization stretch over an immensity of time. But the different halting-places of history are marked by a rate of progress more and more accelerated. It is sufficient to open our eyes simply on our modern world to be amazed by the rapid march of civilization. If, now, through all past time, up to our present days, we contemplate this rapidly

accelerating rate of progress, one primordial factor will appear, which is the soul itself of this accelerated ascent towards a destiny more and more luminous. It is the intensification of the relations between men established by ways of communication.

As soon as the sedentary state of peoples began to succeed the nomad state, the necessity of routes and their enormous utility were instinctively felt; and animal locomotion, whose origin disappears in the night of time, brought even in antiquity the art of route building to a high degree of perfection. The great civilizations of the ancient world were already celebrated for their marvelous roads and maritime routes. Babylonia, Carthage, Greece and the Roman Empire developed majestic routes which excite our admiration; and the traces of some of them still remain. In the civilizations that followed these epochs, in the Middle Ages and the Renaissance, it is easy to note that the march of progress is intimately connected with the development of ways of communication. This fact is generally expressed in speaking of the influence of voyages, of the relations between peoples and the discoveries of new ways and routes. The influence of the technical perfection of the ways of communication is to be seen in a particularly striking manner in the century of steam, marked by such a distinctly powerful progress.

It is impossible to note in a short sketch all the ways in which methods of communication influenced the evolution of humanity. An enormous work could be written on this subject. The essential facts are that almost all human activity on our planet consists in "displacement," and the more easily this displacement is made the more the life of man is extended, and the more powerful it becomes. Our life is built up from motion; to open new routes is to hasten and strengthen its development.

One great factor dominates the whole problem of ways of communication. It is "speed." It is not sufficient to have routes running in all directions and covering great distances; it is all-important for the actual motion to be as rapid as possible. The great influence of speed in the social organization of human activity is not always recognized sufficiently. For example, one can mention the fact that Napoleon in the last years of his power expressed some doubts as to the value of Stephenson's railroads. We must not be astonished if the entire extent of the influence of the speed factor is not realized by all, probably because it is too vast in its majesty and power. But some of us have within ourselves a feeling, more powerful than the conscious reason, which instinctively tells us what speed is. Do you know what speed intoxication is? Happy are those who can

feel it without having to understand it. It is the powerful voice of the innate forces of progress speaking in them. It is the intuition of the future all-inclusive power of humanity, of which, as an echo of destiny, they have the sweet enjoyment. Do you remember the glorious Greek warrior who immolated himself to the speed god, bringing to his fellow-citizens the great news of the Marathon victory, so that their knowledge of social security might be hastened, even by only a few moments? This hero of antiquity, by a striking act, has made immortal his veneration for speed. Great men and great peoples have always paid a worthy tribute to speed. A beautiful example is given by the development of the United States, where the social importance of the speed factor has been understood from the origin of the country, a country which, in the hands of an energetic and intrepid people, has been brought to that powerful and majestic state which we can but admire.

Speed of transportation means acceleration of activity, increase of the people's efficiency, and, as a result, economy of time, with all its enormous consequences. Saving of time brings leisure for meditation and personal improvement, which are the original sources of all progress.

Speed of transportation means also increase of human lifetime, which always was and is one of the most burning desires of man, and hence one of his greatest felicities. To live means to act, to feel and perceive. It is the amount of the perceptions lived that marks the duration of a life-time more than the number of years elapsed. It is not given to us to increase the duration of our lives, but it depends upon us to use our lives better and to fill them with more sensations. I am prepared to assert that the life of a modern man is effectively longer than the life of a man of antiquity, although of the same duration. We have now more to live through, although we live no longer. Our gathering of sensations is much ampler and much more diversified, and they emanate from a much wider horizon. Peter the Great, that powerful reformer of Russia, has expressed this deeply philosophical idea by the significant words: "Waste of time is death-like."

Ask the scientist whether he considers the universe as eternal or doomed to an indubitable end, and you will hear him say that over the entire universe the sinister shadow of the omnipotence of entropy is hovering, and demands an absolute end by a complete thermic uniformization. If, now, not only our personal life, but the course of all humanity is limited, let us at least make the best use of the time left to us. Speed is

our most powerful ally. Let us use it, develop it, and venerate it. It is in infatuation with it that is found the most powerful source of happiness.

Another important rôle is also inherent to the speed factor. One of the great consequences of the establishment of ways of communication is to bring men and peoples to know one another better and consequently to understand each other better and to unite their efforts in the great march of social evolution. The greater the intensification of relations between peoples, the more rapid is the speed of what can be called the uniformization of humanity. In past times, geographical obstacles separated men into different groups called peoples. The conditions under which the lives of different peoples were taking place were unlike, and, although all associations of men, by their nature, progress in the same direction, it is with such dissimilar psychological physiognomies, that, when these different peoples in the process of their evolution were brought together, they could only fight one another to death, each considering the other as his worst enemy. Men did not recognize man in men. But the evolution of man progressing, and distances being conquered by ways of communication, the uniformization of humanity was growing. It is first the uniformization of social customs and material living conditions that is established. Afterwards the uniformization of morality and psychology begins to appear. It is self-evident that social uniformization does not at all bring with it the uniformization of individuals, whose personality is fixed by the qualities and talents given to each man by nature. The great wrong of the Bolsheviki doctrine[1] is that it has completely overlooked the difference between social uniformization and individual uniformization. Regardless of what men will think or do, the whole of humanity will tend towards social uniformization, but individual uniformization is and always will be a tendency contrary to the nature of things and progress. That is why, regardless of the development it may reach, Bolshevism is doomed to failure or complete reformation. I will not dwell here on the question of how social organization has to be conceived in agreement with the principle of social uniformization; this would carry us too far from our main subject. Now this fundamental process of social uniformization is far from being accomplished on our planet. But I would like to believe that the Great War, from

[1] The author of this paper has lived for six months under Bolsheviki rule and is well acquainted with Bolsheviki doctrine and its practical realization.

which we are still bleeding, marks one of its last halting-places. The World's Peace, the universal social union, will only then be able to reign in all its luminous beauty when the process of social uniformization shall have reached a certain stage of development. The most powerful stimulant to universal social uniformization is above all the closeness of international relations. The more rapid are the means of communication, the more will all peoples be, so to speak, neighbors to one another, the more will they jostle one another and be able to know and appreciate each other, and the great universal human family will rise the more rapidly. The century of steam and electricity has already brought the universe to such a state of development that we see on the horizon the dawn of a universal league, somewhat rachitic, but let us hope still a league of nations. It is a wonderful thought indeed, in our epoch of sharp hate and underhanded revenge, to see the great country of America, in a magnanimous glow in advance of the men and the times, claiming with its powerful voice the union of people in the League of Nations. Universal harmony is the highest ideal of every man conscious of his destiny. Let us help those who have not until now reached the social height necessary to step over the marvelous threshold of the future kingdom of mutual agreement and friendship.

The life of man goes on surrounded by three "elements": earth, water and air. Each of these may be used as a way of communication.

On the earth we must trace our routes, and when these are once established we must always follow them. Terrestrial routes have passed through different well-known stages of development and have now reached a high degree of perfection, in the sense of speed as well as in weight of material transported. But whatever improvements may be realized in terrestrial routes, the fact will always remain that the roads have to be built, and when built they remain limited to their original itinerary, and unite only different parts of the same continent.

Water ways have the advantage over land ones of being furnished by nature; and in the immensity of the seas and oceans ships and boats are free to follow all directions. But the hatreds between men, even here, have created insuperable hindrances; some think, for the advantage of the one and the harm of the other, but in reality for the disaster of all humanity. Moreover, water ways unite only different parts of different continents, or, by rivers, give only a limited access within the continents.

The conquest of the air, the marvelous realization of the end of the twentieth century, has finally given us the aerial way of communication, the first to be universal. Air routes have absolute advantage over earth and sea routes, for instance, in the attainment of greater speed, and the possibility of travel at different altitudes. This last factor can never be overestimated, on account of the new features it introduces. At least there has been acquired by it the possibility of looking on our planet from a higher standpoint, and many consequences of great importance will follow from this bird's vision given to man's brains. It has been during long centuries the dream of humanity to fly over seas and lands, to travel through space in rapid flight, following only the will of fancy. But, the first enthusiasm past, when airplanes and airships began to fly, their range appeared to be less than the expectations of the dreamers. Aircraft could fly over earth and seas, but the oceans still remained obstacles to them. And although we felt the possibility of flight over the ocean, we were unable to realize it. The universality of the air routes still remained unrealized. But the scientific and technical workers and investigators by their indefatigable efforts have brought aircraft to such a degree of perfection that finally the immensity of the ocean has been overcome. From this moment on, aircraft has become really the first universal way of communication. I can not refrain from mentioning here some of the glorious names of those men to whom humanity owes the great technical development of aviation.

It was probably the British mathematician Cayley who had the first vision of the airplane (1809). It was the French mathematician Penaud who reached such an understanding of aerodynamical sustentation that he was able to build the first airplane model that actually flew (1872). But it was the German engineer Lillienthal who first reached the wonderful result of making the air really lift him, as he demonstrated in a brilliant series of gliding flights (1891). It was Langley and Chanute who, by remarkable experiments, strengthened the principles established by Lillienthal. And finally, it was the brothers Wright who succeeded in taking the decisive step and realized that marvelous thing, the airplane (1903). In the European countries it is to the powerful personality of Ferber that we owe the development of aviation. In a remarkable book[2] left by this scientist and gallant prophet of aviation we

[2] F. Ferber, "L'Aviation, ses debuts, son developpement," Paris, 1908, published by Berger-Levrault.

read his forecast: "From hill to hill, from town to town, from continent to continent." It is the realization of these beautiful words that we have now reached.

We thus find ourselves now on the eve of the establishment of great universal aerial voyages, transoceanic as well as transcontinental; and with them, by the power of the intensification of the relations between peoples, we will progress towards universal harmony, and approach, in spite of obstacles, a luminous destiny at a rate of progress unknown before.

Let all who still doubt the all-powerful influence of universal air routes think only a little of your daily activity, and you can not help being enthusiastic about all the new and wonderful possibilities that the development of air navigation will give you. Whoever you are, air navigation will load you with its powerful benefits. If you are a business man or merchant, one of those who have appreciated better than others the speed factor, think for a minute that you will have the neighboring continents at a day's distance from you. Your associates from other continents will be able to join you in twenty-four hours. The samples that you may need will be delivered to you on your request in the same length of time. You will be able to travel over enormous distances at tremendous speeds, and scrutinize enormous spaces by your spirit of enterprise. If you are an engineer, scientist or investigator, you will be able to get the necessary book, apparatus or information from any other part of the world in a time less than previously required to get the same from the same province. Think a little, you leaders of human activity, of all the wonderful possibilities that will follow from the new aerial universal ultra-rapid routes, and your keen minds will not need to be convinced of the miraculous activity of future destiny. And all you other less active members of human society, in addition to the comfort, speed, and security of the air routes, you will see flowing around, as from a cornucopia, the products of welfare created by the active members. But all these results just described are small details in comparison with the new human psychology which will progressively result from this era of activity at a rate unknown before, and which without any doubt will reveal to the future the superman of spirit, soul and beauty.

The crossing of the ocean by the airplane makes aircraft the first universal means of transportation, and by this fact alone opens a new era of civilization, with such an increased rate of progress that it is almost impossible for the human mind of to-day to appreciate its whole significance. Acceleration of

human activity will increase the world's welfare; and at the same time the resulting economy of time and individual liberty will lead to the perfecting of the human race in a deep and increasing feeling of happiness, the result of the intensification and multiplicity of sensations, this whole wonderful process of progressive evolution being crowned by the spirit of universal harmony. Aircraft, having become by the crossing of the ocean the universal means of transportation, thus appear as one of the most sublime conquests of civilization, by whose luminous destiny our poor imaginations can only be dazzled.

But this wonderful destiny, which we now foresee, whose rising has begun and the means of reaching which we have already in hand, will require a certain time for its blossoming. Such delay in the realization of one of the most beautiful conquests of humanity is a consequence of what, with much indulgence, is called social inertia. I do not wish to enter into the details and the analysis of this complex phenomenon, and will mention only one of its most painful sides. I apologize for stating the fact so directly. I am guided only by the desire to bring in this way a more intensive feeling of what I intend to say. Why do you, humanity, let yourself be governed by the most ignorant among your fellow-creatures? I will explain myself plainly. At the present time the social power, to a crushing degree, is in the hands of what may be called the "classical humanists." Who are they? Independent of their literary, juristical or other specialty, their mentality once cleared from the sophistical fog with which they are so clever in surrounding themselves; with their official logic, which is nothing else than a brilliant example of reasoning to be used when truth has to be avoided, we see them appearing only as experts in the dismal art of knowing the degree of decay which human nature can reach. It is exactly the contrary of what we need the most, that is, to know what is the degree of perfection that humanity can reach. The ethics of the classical humanist developed under such conditions is not in line with sufficiently powerful and valuable ideals. This is why their political activity provokes so often such social disaster. But to-day we are standing on the eve of a marvelous new era. Among the seekers for truth, among the scientists, engineers, and experts in different technical arts, a new ethics has grown, animated by the most powerful and magnanimous sentiments of justice and universal benevolence, to which they have been brought by the contemplation and study of nature. It is upon the ethics of the men who have an exact knowledge of these con-

crete facts that depends the welfare of humanity. It is by these competent and best men of humanity, masters of the physical world, that the people ought to let themselves be led. The fight between the two tendencies has already begun. It is the fight between the ethics of scholastic ignorance and the ethics of scientific verity. This fight is an old one, but has taken in modern times a new form. It is to Dr. George Sarton, professor of Harvard University, that we owe a brilliant, vigorous and rigorous exposé of this social state of things, which he designates by a name full of destiny, "The New Humanism."[3] Any eloquence of mine would disappear before the words of full conviction of this defender of one of the most beautiful social movements, the understanding of which will without any doubt make us avoid many disasters of the future. Workers in science and technical arts, you have the duty of uniting about the powerful ideals of the "New Humanism," and it will not be long till the light of welfare will pierce the darkness of the classical humanist. The fate of humanity is in progress; this is why the victory of the "New Humanism" can not be stopped. But let us reach it by the peaceful way of conscious evolution, and not by the way of bloody revolution, whose specter stands ready to spread itself over the earth's surface. Modern humanity has a long step to make; it is that of emancipation from the prejudice of the classical humanist. Let us take this step heroically, having the courage to recognize our errors without persisting in our mistakes, without concealing by the sophistries of the classical humanists the actual social wounds, and without crushing by ignorance the benefits of science.

To see how far science is from being sufficiently appreciated to-day, it is enough to compare in the budget of any state the appropriation for science and the appropriations for criminality, for example, this last word being understood in its widest sense. The comparison is illuminating. I will not insist on this painful side of modern social life.

I have considered it necessary to mention here the "New Humanism" for the purpose of showing that the evolution of humanity, although bound up with technical conquests, depends, for the rapidity of its progress, also in a large measure upon social morality. The one brings the other with it.

I allow myself to express the intense desire to see the universe conquered by the "New Humanism," spreading through

[3] George Sarton's "Le Nouvel Humanisme," *Scientia*, March, 1918; see also THE SCIENTIFIC MONTHLY, September, 1918, "The Teaching of the History of Science."

the earth by the powerful transcontinental and transoceanic air routes; and then it will not be long before universal peace, so longed for by every one, becomes a natural phenomenon.

Since the origin of the universe, the complete conquest of the air, now realized by the crossing of the ocean, is the most important factor ever reached in the evolution of humanity.

The history of all mankind is merely the history of its fight against slavery by the forces of nature. Science is our powerful liberator; it teaches us how to use these forces for our own benefit. How many billions of mechanical horsepower are already working for us! To them we owe all the beauty of modern civilization. Workers in technical arts and sciences, you must be firm in your convictions, in the face of social ignorance; your efforts are tracing the path of man's highest destiny.[4]

[4] It is a special pleasure for the author to address his heartiest thanks to Dr. J. S. Ames for the help he gave him in correcting the style of this article.

# WAIYAUTITSA OF ZUÑI, NEW MEXICO

By ELSIE CLEWS PARSONS

NEW YORK CITY

ONLY twice through my association with Pueblo Indians has it occurred to me to be a feminist. The first time was at Cochiti when late at night my tired and sleepy Indian hostess grumbled in the soft tones no Pueblo woman ever loses, grumbled because she had to sit up for the young husband who was spending the evening at the club, *i. e.*, taking part in a ceremonial at the estufa. "I'll have to get him something to eat," she said, "no man here would ever cook for himself at home. They say if they did, they would lose their sense of the trail." Rationalization of habit or desire is not confined to the peoples of western civilization.

The second time I remembered I was a feminist was when the editor of a certain journal asked me to write an article on Zuñi women. Are the women of a community still thought of, I queried, even in scientific or pseudo-scientific circles, as a separable class? If so, there is nothing for us but to keep on with the categories of feminist and anti-feminist, tiresome though they become.

Well, the article was written, but it was not published because it contained a reference to the lack of prostitution at Zuñi. Recognition of the subject was considered unsuitable for boy and girl readers; it was deemed better for them to have a partial survey of the facts of life than to see life whole, even at Zuñi. Nor was life at Zuñi to suggest inquiry into life at home.

But writing the article served at least one purpose. It focused attention upon the differentiation of the sexes at Zuñi and resulted in an analysis which contributed to the understanding of a considerable portion of Zuñi habits of mind and of culture. To get the survey which leads to the analysis, let us follow the life of a baby girl we shall call Waiyautitsa, a girl's name, for sex generally appears in Zuñi personal names. Sex appears somewhat in speech too. Waiyautitsa in learning to talk will make use of expressions, particularly exclamations, peculiar to women. Recently Dr. Kroeber, in giving us a list of

the first words used by a Zuñi child, a boy, noted the comparatively large number of kinship terms in his vocabulary. The kinship terms of our imaginary little girl would be somewhat different from a boy's. He calls a younger sister *ikina;* a younger brother, *suwe;* she calls either *hani,* meaning merely the younger. And, as the Zuñi system of kinship terms is what is called classificatory, cousins having the same terms as brother and sister, Waiyautitsa has even fewer words than her brother to express cousinship.

When Waiyautitsa is three or four years old she may be recognized as a girl not merely from her speech, but from her dress, from her cotton slip; at this age little boys wear trousers. But not for another three or four years, perhaps longer, will Waiyautitsa wear over her cotton slip the characteristic Pueblo woman's dress,—the black blanket dress fastened on the left shoulder and under the right arm and hence called in Zuñi *watone,* meaning "across," the broad belt woven of white, green and red cotton, the store-bought kerchief or square of silk (*pitone*) which, fastened in front, hangs across shoulders and back, and the small foot, thick leg moccasins which cover ankle and calf in an envelope of fold upon fold of buckskin. Before Waiyautitsa is eight or even six she may, however, when she goes out, cover her head and body with a black blanket or with the gay colored "shawl" similarly worn. And I have seen very little girls indeed wearing moccasins or the footless black stockings Zuñi women also wear, or "dressing up" in a *pitone,* that purely ornamental article of dress without which no Zuñi woman would venture outdoors. Without her *pitone* she would feel naked, she says, and any man would be at liberty to speak disrespectfully to her. When Waiyautitsa is about five, her hair, before this worn, like the boys, in a short cut, is let grow into a little tail on the nape of her neck. In course of time her pigtail will be turned up and tied with a "hair belt" of white, green and red cloth. From ear to ear her front hair will be banged to the end of her nose, the bang drawn sidewise above the forehead except at such times in ceremonials when it is let fall forward to conceal the upper part of the face.

This hair arrangement serves in ceremonials as a kind of mask. A mask proper, that *quasi* fetich which has so important a place in Pueblo ceremonialism, Waiyautitsa will in all probability never wear. Unlike her brother, Waiyautitsa will not be initiated in childhod into the *kotikyane* or god society, and consequently she will not join one of the six *kiwitsiwe* or sacred club-houses or estufas which supply personators for the

masked "dancers." Not that female personages do not figure in these ceremonials, but as was the rule on the Elizabethan stage women are impersonated by men.

To this exclusion of girls from the *kotikyane* and from participating in the masked "dances" there are, we should note, a few exceptions. To-day three women belong to the *kotikyane*. They were taken into it not in childhood, but in later life and, it is said, for one of the same reasons women as well as men are taken into the other fraternities or societies of Zuñi. Cured by ceremonial whipping of the bad effects of nightmare or of some other ailment, they were "given" to the *kiwitsine* credited through one of its members with the cure. Of the three women members only one is said to dance, and she is accounted mannish, *katsotse*, girl-man, a tomboy.

Waiyautitsa will not be initiated, it is not very likely, into the *kotikyane*, but she is quite likely to be initiated into another society,—into the Great Fire or Little Fire or Bed Bug or Ant or Wood society, into any one of the thirteen Zuñi societies except three, the bow priesthood or society of warriors, of warriors who have taken a scalp, or the Hunter Society or the Cactus Society, a society that cures arrow or gun-shot wounds. As women do not hunt or go to war, from membership in these groups they are excluded or, better say, precluded. As we shall see later, affiliation by sex is in ceremonial affairs along the lines of customary occupation.

If Waiyautitsa falls sick and is cured by a medicine-man of the medicine order of a society she must be "given" either to the family of the medicine man or to his society. Initiated she may not be, however, for a long time afterwards, perhaps for years. Initiations take place in the winter when school is in session, the school either of the Indian Bureau or of the Dutch Reformed Church, and for that reason, it is said, initiations may be postponed until past school age. Despite the schools, I may say, I have met but two Zuñi women who speak English with any fluency. One woman is a member of the Snake-Medicine Society, into which she was initiated after convalescence from measles, a decimating disease at Zuñi, to be accounted for only through witchcraft. The other woman was accounted the solitary convert of the Dutch Reform Church Mission in Zuñi until six or seven years ago she joined the Wood society because as a child she had been cured by them of smallpox.

After initiation, the women, like the men of a society, offer feather-sticks each moon, observing continence for four days

thereafter, and they join in the four-day retreat in the ceremonial house of the society preliminary to an initiation. Unlike the men, however, the women do not spend the entire night, only the evening, in the society house, and, while there, they are listeners rather than narrators of the inexhaustible folk tales that are wont to be told at society gatherings. Men are the custodians of the lore, secular as well as esoteric, of the tribe, just as men and not women are the musicians. The men are devoted singers, singing as they dance or singing as a choir for dancers, and singing as they go to or from work in the fields or as they drive their horses to water in the river or to the corrals on the edges of the town. Even grinding songs are sung on ceremonial occasions by men.

In the public appearances of the society, the women members figure but little. Societies supply choirs and drummers and ceremonial road openers or leaders to the masked dancers and, during the great *koko awia* (god coming) or *shalako* ceremonial, to various groups of sacred personages. I have seen several "dances" in Zuñi and one celebration of *koko awia*, and I have seen but one woman officiate in public. As a daughter of the house which was entertaining the *koyemshi* or sacred clowns she was in attendance upon that group in the *koko awia* or Advent, so to speak, of 1915.

If Waiyautitsa belongs to a society, she will offer or plant the befeathered prayer-sticks, which are so conspicuous a feature of Pueblo religion, but, being a woman, Waiyautitsa will not cut or dress the sticks. She will only grind the pigments and, perhaps, paint the sticks. Nor as a woman would she offer the sticks on certain other ceremonial occasions when the men offer them. Once a year, however, at the winter solstice ceremonial on which so much of Zuñi ritualism pivots, Waiyautitsa will be expected, even in infancy, to plant, planting for the "old ones," *i. e.*, the ancestors and for the Moon, but not, like the men, for the Sun or, unless a member of the *kotikyane*, for the ancestral gods, the *koko*.

At the conclusion of the winter solstice ceremonial, when certain sacred figures called *kwelele* go from house to house, the women carry embers around the walls of the house and throw them out on the *kwelele*. It is a rite of *shuwaha*, cleansing, exorcism. There are a number of other little rites peculiar to the women in Zuñi ceremonialism. Through them, and through a number of rites they share with the men, through provisions for supplying food in the *kiwitsine* to the sacred personators or for entertaining them at home or making them

presents, women have an integral part in Zuñi ceremonialism. In what we may call the ceremonial management, however, they appear to have little or no part.

Even when women are initiated into the *kotikyane*, or are associated with the *ashiwanni* or rain priests, their functions seem to be primarily of an economic or housekeeping order. The women members of the rain priesthoods have to offer food every day to the fetiches of these sacerdotal groups—to stones carved and uncarved and to cotton wrapped lengths of cane filled with "the seeds the people live by." For the seed fetiches to be in any way disturbed in the houses to which they are attached involves great danger to the people and on a woman in the house, the woman member of the priesthood, falls the responsibility of guardianship or shelter. But even these positions of trust are no longer held by women—there are, according to Dr. Kroeber, only six women *ashiwanni* among the fifteen priesthoods. The woman's position among the paramount priesthood, the rain priesthood of the North, has been vacant now for many years—no suitable woman being willing, they say, to run the risks or be under the taboos of office. Aside from this position of woman *shiwanni*, women count for little or nothing in the theocracy of Zuñi. They were and are associated with the men priests to do the work pertinent to women. In the case of the Zuñi pantheon or its masked impersonations, the association is needed to satisfy or carry out, so to speak, Zuñi standards or concepts of conjugality. The couple rather than the individual is the Zuñi unit. Sometimes, in ceremony or in myth, the couple may consist of two males.

There is one masked couple I have noted in particular at Zuñi, the *atoshle*. Two or three times during the winter our little Waiyautitsa together with other girls and very little boys may expect to be frightened by the *atoshle*, the disciplinary masks who serve as bugaboos to children as well as a kind of sergeant-at-arms, the male *atoshle* at least, for adults. If the children meet the old man and his old woman in the street, they run away helter skelter. If the dreadful couple visits a child indoors, sent for perhaps by a parent, the child is indeed badly frightened. I suppose that Waiyautitsa is six or seven years old when one day, as an incident of some dance, the *atoshle* "come out" and come to her house. The old woman *atoshle* carries a deep basket on her back in which to carry off naughty children and in her hand a crook to catch them by the ankle. With the crook she pulls Waiyautitsa over to the grinding stones in the corner of the room, telling her that now she is

getting old enough to help her mother about the house, to look after the baby and, before so very long, to grind. She must mind her mother and be a good girl. I once saw a little girl so terrified by such admonition—this time by the old man *atoshle*, the old woman not being along—that she began to whimper, hiding her head in her mother's lap until the *atoshle* was sprinkled with the sacred meal and left the house to perform elsewhere his rôle of parents' assistant.

Whether from fear, from supernatural fear or fear of being talked about as any Zuñi woman who rests or idles is talked about, or whether from example, more from the latter no doubt than from the former, Waiyautitsa is certainly a "good girl," a gentle little creature, and very docile. Through imitating her industrious mother or aunt or her even more industrious grandmother or great-aunt, she learns to do all the household tasks of women. She learns to grind the corn on the stone *metate*—that back-hardening labor of the Pueblo woman—and to prepare and cook the meal in a number of ways in an outside oven or on the American stove or on the flat slab on which *hewe* or wafer bread is spread. For the ever cheery family meal she sets out the coffee-pot, the *hewe* or *tortilla*, and the bowls of chile and of mutton stew on the earthen floor she is forever sweeping up with her little home-made brush or with an American broom. (A Zuñi house is kept very clean and amazingly neat and orderly.)

And Waiyautitsa becomes very thrifty—not only naturally but supernaturally. She will not sell corn out of the house without keeping back a few grains in order that the corn may return—in Zuñi thought the whole follows a part. And she will keep a lump of salt in the corn store room and another in the bread bowl—when salt is dug out, the hole soon refills, and this virtue of replacing itself the salt is expected to impart to the corn. There are other respects, too, in which Waiyautitsa will learn how to facilitate the economy. She will sprinkle the melon seeds for planting with sweetened water—melons should be sweet. Seed wheat she will sprinkle with a white clay to make the crop white, and with a plant called *ko'wa* so that wheat dough will pull well. Seed corn will be sprinkled with water that the crop may be well rained on.

From some kinswoman who is a specially good potter Waiyautitsa may have learned to coil and paint and fire the bowls as well as the cook pots and water jars the household needs. She fetches in wood from the wood-pile and now and again she may be seen chopping the pine or cedar logs the men

of the household have brought in on donkey or in wagon. She fetches water from one of the modern wells of the town, carrying it in a jar on her head and walking in the slow and springless gait always characteristic of Pueblo women. That gait, let me say, so ponderous and so different from the gait of the men, is one of the puzzling things about Pueblo women. Is it perhaps the result of their incessant industry, a kind of unconscious self-protective device against "speeding up"?

Waiyautitsa will learn to work outdoors as well as in. She will help her mother in keeping one of the small gardens near the town—the men cultivate the outlying fields of corn and wheat (and the men and boys herd the sheep which make the Zuñi prosperous), and Waiyautitsa will help her household thresh their wheat crop, in the morning preparing dinner for the workers, for relatives from other households as well as from her own, in the afternoon joining the threshers as the men drive horses or mules around the circular threshing floor and the women and girls pitch-fork the wheat and brush away the chaff and winnow the grain in baskets. Waiyautitsa will also learn to make adobe blocks and to plaster with her bare hand or with a rabbit-skin glove the adobe walls of her mother's house, inside and out. Pueblo men are the carpenters of a house, but the women are always the plasterers, and Waiyautitsa will have to be a very old woman indeed to think she is too old to plaster. On my last visit to Zuñi I saw a woman seventy or not much under spending part of an afternoon on her knees plastering the chinks of a door-newly cut between two rooms.

The house she plasters belongs or will in time belong to Waiyautitsa. Zuñi women own their houses and their gardens or, perhaps it is better to say, gardens and houses belong to the family through the women. At marriage a girl does not leave home; her husband joins her household. He stays in it, too, only as long as he is welcome. If he is lazy, if he fails to bring in wood, if he fails to contribute the produce of his fields, or if some one else for some other reason is preferred, his wife expects him to leave her household. He does not wait to be told twice. "The Zuñi separate whenever they quarrel or get tired of each other," a critical Acoma moralist once said to me. The monogamy of Zuñi is, to be sure, rather brittle. In separation the children stay with the mother.

Children belong to their mother's clan. They have affiliations, however, as we shall see, with the clan of their father. If the mother of Waiyautitsa is a Badger, let us say, and her

father a Turkey, Waiyautitsa will be a Badger and "the child of the Turkey." She can not marry a Turkey clansman nor, of course, a Badger. Did she show any partiality for a clansman, an almost incredible thing, she would be told she was just like a dog or a burro.

These exogamous restrictions aside and the like restrictions that may arise in special ways between the household of Waiyautitsa and other households, Waiyautitsa would be given, I am told, freedom of choice in marrying. Even if her household did not like her man, and her parents had told her not "to talk to" him, Zuñi for courting, she and he could go to live with some kinswoman. No one, related or unrelated, would refuse to take them in. In Zuñi nobody may be turned from the door. Nor would a girl whose child was the offspring of a chance encounter be turned out by her people or slighted. The illegitimate child is not discriminated against at Zuñi.

Casual relationships occur at Zuñi, but they are not commercialized, there is no prostitution. Nor is there any life-long celibacy. As for courtship, how there can be any, at least before intimacy either in the more transient or more permanent forms of mating, is a puzzle—the separation outside of the household of boys and girls of various ages is so thorough. "But what if a little girl wanted to play with boys?" I once asked. "They would laugh at her and say she was too crazy about boys." "Crazy" at Zuñi, as quite generally among Indians, means passionate. (Girls at Zuñi are warned away from ceremonial trespass by the threat of becoming "crazy.")

The young men and the girls do, to be sure, have non-ceremonial dances together, and in preparing for them there may be opportunities for personal acquaintance. The dance itself seems too formal for such opportunities. I saw one of these dances not long ago. It was a Comanche dance. There were a choir of about a dozen youths including the drummer, four girl dancers heavily beringed and benecklaced, the pattern of whose dance, two by two or in line, was very regular, and a youth who executed in front of them or around them an animated and very beautiful *pas seul*. After dancing outside in the plaza, they all went into "the saints house" to dance for her "because they like her"—a survival no doubt of the custom of dancing in the Catholic church observed by the Indians in Mexico and not long since quite generally in New Mexico. During this same visit to Zuñi, I may say, I also saw one late afternoon, a time for fetching water, a young man take a girl rather brusquely by the arm and try to speak to her. She

averted her head and passed on, another girl only a few steps ahead of her and another not far behind. It was the briefest of encounters and far from private, but it left me no longer quite as sceptical as I had been on being told that at this twilight hour, at least, the girls and the young men do meet. And after "two or four" meetings at the well a girl may agree to marry or, in Zuñi phrase, to have a man.

Well, Waiyautitsa has in one way or another, we shall have to suppose, met her young man and agreed that he is to join her household. At first, for a few days, he will stay in the common room, in the room where all sleep (sleeping and dressing, let me say, with the utmost modesty), he will stay only at night, leaving before dawn, "staying still" his shyness is called. Then he will begin to eat his meals with the household. There is, you see, no wedding ceremonial and a man slips as easily as he can into the life of his wife's household. The Ashiwi, as the people call themselves, take no pleasure in disconcerting one another—ceremonially, at least—nor does the priesthood aim to direct domestic events.

Waiyautitsa will pay a formal visit on her bridegroom's people, taking his mother a basket of corn meal. To Waiyautitsa herself her young man will have given a present of cloth for a dress or a buckskin for the moccasins he will make for her. Hides are a product of the chase, of cattle raising (cowhide is used to sole moccasins), or of trade, men's occupations, and so moccasins of both women and men are made by men. Women make their own dresses, although, formerly, before weaving went out of fashion at Zuñi, it is likely that men were the weavers, just as they are to-day among the Hopi from whom the men of Zuñi get cloth for their ceremonial kilts and blankets and for the dresses of the women. Even to-day at Zuñi men may make up their own garments from store bought goods and it is not unusual to see a man sitting to a sewing-machine.

A man may use cloth or thread for other than economic reasons. In case a girl jilts him he will catch her out some night and take a bit from her belt to fasten to a tree on a windy mesa top. As the wind wears away the thread, the woman will sicken and perhaps in two or three years die.[1] A woman who is deserted may take soil from the man's footprints and put it where she sleeps. At night he will think of her and come back—"even if the other woman is better looking." Apprehensive of

[1] Analogous reasoning leads to the practise of burning scraps in dressmaking that they may not fall into the hands of a witch.

desertion a woman may put a lock of hair from the man in her house wall or, the better to attach him to her, she may wear it over her heart. Women and men alike may buy love charms from the *newekive*, a curing society potent in magic, black or white. There is a song, too, which men and women may sing "in their heart" to charm the opposite sex. And there is a song which a girl may sing to the corn as she rubs the yellow meal on her face before going out. "Help me," is the substance of it, "I am going to the plaza. Make me look pretty." Rarely do our girls pray, I suppose, when they powder their noses.

Courtship past for the time being, courtship by magic or otherwise, Waiyautitsa is now, let us say, an expectant mother. Her household duties continue to be about the same, but certain precautions, if she inclines to be very circumspect, she does take. She will not test the heat of her oven by sprinkling it in the usual way with bran, for if she does, her child, she has heard, may be born with a skin eruption. Nor will she look at a corpse or help dress a dead animal lest her child be born dead or disfigured. She has heard that even as a little girl if she ate the whitish leaf of the corn husk her child would be an albino. If her husband eat this during the pregnancy the result would be the same. On her husband fall a number of other pregnancy taboos, perhaps as many as fall on her, if not more. If he hunts and maims an animal, the child will be similarly maimed —deformed or perhaps blind. If he joins in a masked dance, the child may have some mask-suggested misshape or some eruption like the paint on the mask. If he sings a great deal, the child will be a cry baby. The habit of thinking in terms of sympathetic magic or of reasoning by analogy which is even more conspicuous at Zuñi than, let us say, at New York, is particularly evident in pregnancy or birth practises or taboos.

Perhaps Waiyautitsa has wished to determine the sex of the child. In that case she may have made a pilgrimage with a rain priest to Towa Yalene, the high mesa three miles to the east of the town, to plant a feather-stick which has to be cut and painted in one way for a boy, in another way for a girl. (Throughout the Southwest blue or turquoise is associated with maleness and yellow with femaleness.) Wanting a girl, and girls are wanted in Zuñi quite as much as boys, if not more, Waiyautitsa need not make the trip to the mesa, instead her husband may bring her to wear in her belt scrapings from a stone in a phallic shrine near the mesa. When labor sets in and the pains are slight, indicating, women think, a girl, Waiyautitsa

may be told by her mother, "Don't sleep, or you will have a boy." A nap during labor effects a change of sex. When the child is about to be born, Waiyautitsa is careful, too, if she wants a girl, to see that the custom of sending the men out of the house at this time is strictly observed.

After the birth, Waiyautitsa will lie in for several days, four, eight, ten or twelve, according to the custom of her family. Whatever the custom, if she does not observe it, she runs the risk of "drying up" and dying. She lies on a bed of sand heated by hot stones, and upon her abdomen is placed a hot stone. Thus is she "cooked," people say, and creatures whose mothers are not thus treated are called uncooked, raw—they are the animals, the gods, Whites. To be "cooked" seems to be tantamount in Zuñi to being human.

It is the duty of Waiyautitsa's mother-in-law, the child's paternal grandmother, to look after mother and child during the confinement, and at its close to carry the child outdoors at dawn and present him or her to the Sun. Had Waiyautitsa lost children, she might have invited a propitious friend, some woman who had had many children and lost none, to attend the birth and be the first to pick up the child and blow into his mouth. In these circumstances the woman's husband would become the initiator of the child, if a boy, when the child was to be taken into the *kotikyane*. Generally the child's father choses some man from the house of his own *kuku* or paternal aunt to be the initiator or godfather, so to speak, of the child.

The infant will receive many attentions, too, from his mother and her household. He is placed on a cradle board in which, near the position of his heart, a bit of turquoise is inlaid to preclude the cradle bringing any harm to its tenant. Left alone, a baby runs great risk—some family ghost may come and hold him, causing him to die within four days. And so a quasi fetichistic ear of corn, a double ear thought of as mother and child, is left alongside the baby as a protector. That the baby may teeth promptly, his gums may be rubbed by one who has been bitten by a snake—"snakes want to bite." To make the child's hair grow long and thick, his grandfather or uncle may puff the smoke of native tobacco on his head. That the child may not be afraid in the dark, water-soaked embers are rubbed over his heart the first time he is taken out at night—judging from what I have seen of Zuñi children and adults a quite ineffectual method. That the child may keep well and walk early, hairs from a deer are burned and the child held over the smoke —deer are never sick and rapid is their gait. Their hearing,

too, is acute, so discharge from a deer's ear will be put into the baby's ear. That the child may talk well and with tongues, the tongue of a snared mocking-bird may be cut out and held to the baby to lick. The bird will then be released in order that, as it regains its tongue and "talks," the child will talk. A youth who speaks in addition to his native tongue Keresan, English and Spanish has been pointed out to me as one who had licked mocking-bird tongue.

Waiyautitsa will give birth to three or four children, let us say, probably not more, and then, as she approaches middle age, let us suppose she falls sick, and after being doctored unsuccessfully first by her old father who happens to be a well-known medicine-man of the Great Fire society, and then by a medicine-man from the *newekwa* society whose practice is just the opposite, Waiyautitsa dies. Within a few hours elderly kinswomen of her father's will come in and wash her hair and body, and at dawn sprinkle her face first with water and then with meal. The deceased will be well dressed, and in a blanket donated by her father's people she will be carried to the cemetery lying in front of the old church, a ruin from the days of the Catholic establishment in Zuñi. There to the north of the central wooden cross, *i. e.*, on the north side of the cemetery, Waiyautitsa will be buried. Women are always buried on the north side and men on the south.

Waiyautitsa will be carried out and buried by her father's kinsmen or clansmen. No woman will go to the burial, nor will the widower. The widower, as soon as the corpse is taken outdoors, will be fetched by his women relatives to live at their house. There they straightway wash his hair—a performance inseparable in Zuñi as at other pueblos from every time of crisis or ceremony. The hair of all the other members of Waiyautitsa's household will be washed at the end of four days by women relatives of her father. During this time, since the spirit of Waiyautitsa is thought to linger about the home, the house door will be left open for her at night. The bowl used in washing her hair and the implements used in digging her grave will also be left outdoors. Her smaller and peculiarly personal possessions have been buried with her and bulky things like bedding have been burned or taken to a special place down the river to be buried. The river flows to the lake sixty miles or so west of Zuñi where Waiyautitsa's spirit is also supposed to take its journey. There under the lake it abides except when with other spirits it returns in the clouds to Zuñi to pour down the beneficent rain. People will say to a child, when they

see a heavy cloud, "There goes your grandmother," or they will quite seriously say to one another, "Our grandfathers are coming."

Waiyautitsa's children may go on living at home with their grandmother, Waiyautitsa's mother, or it may be one of them is adopted by a maternal aunt or great-aunt or cousin. Zuñi children, cherished possessions as they are, are always being adopted—even in the lifetime of their mother. Adopted, a child—or an adult—will fit thoroughly into the ways of his adoptive household. It is the household as well as the clan which differentiates the Zuñi family group from our individualistic type of family. The household changes quite readily, but whatever its composition, it is an exceedingly integrated and responsible group.

However the children are distributed, it will be the older woman or women in the household who will control them. This household system is one that gives position and considerable authority to the elder women—until the women are too old, people say, to be of any use. (In spite of this irony, I have heard of but one old woman who was neglected by her household.) An older woman who is the female head of the household is greatly respected by her daughters and sons-in-law and grandchildren as well as by the sons or brothers who continually visit the household and often, as temporary celibates, return to live in it.

The older woman is highly esteemed, but she is by no means the head of the household—unless she is widowed. Wherever the household contributes to the ceremonial public life, her husband is paramount. In the non-ceremonial, economic life, too, he has equal, if not greater, authority. And in the general economy he more or less expects his wife to serve him and wait on him. This conjugal subordination is not apparent to any extent among the younger people; the younger husband and wife are too much drawn into the cooperate household life. But as time passes and they in turn become the heads of the household, the man appears to be more given to staying at home, and more and more he takes control.

From this brief survey of the life of a woman at Zuñi in so far as it can be distinguished from the general life, we get the impression that the differentiation of the sexes follows lines of least resistance which start from a fairly fundamental division of labor. From being hunters and trappers men become herders of the domestic animals, drivers or riders. Trade journeys and trips for wood or for the collecting of other natural resources

are associated with men, and work on the things acquired is men's work—men, for example, are wood cutters, and bead makers, whether the objects are for secular or sacerdotal use. Analogously all work upon skins or feathers is work for men whether it leads to the manufacture of clothing or to communication with the supernaturals. Again, as farmers, men are associated with that system of supernatural instrumentalism for fertility and weather control which constitutes in large part Zuñi religion. In other words, the bulk of the ceremonial life, a system for the most part of rain rituals, is in the hands of the men. So is government. The secular officers are merely representatives of the priests. Zuñi government is a theocracy in which women have no part. The house and housekeeping are associated with women. Clay is the flesh of a female supernatural and clay processes, brick making or laying or plastering, and pottery making are women's work. There are indications in sacerdotal circles that painting is or was thought of as a feminine activity. Corn, like clay, is the flesh of female supernaturals, and the corn is associated with women. Even men corn growers are in duty bound to bring their product to their wife or mother. Women or women impersonations figure in corn rituals. It is tempting to speculate that formerly, centuries since, women themselves were the corn growers. To-day, at any rate, the preparation of corn as of other food is women's work. Wherever food and its distribution figure in ceremonials, and there is a constant offering of food to the supernaturals, women are apt to figure. Fetiches are attached to houses and in so far as providing for these fetiches is household work it is women's work and leads to the holding of sacerdotal office by women. The household rather than ties of blood is the basis of family life. The children of the household are more closely attached to the women than to the men. One expression of this attachment is seen in reckoning clan membership through the mother.

Household work at Zuñi as elsewhere is continuous. The women are always on the move. The work of the men, on the other hand, is intermittent. Hunting, herding and farming are more or less seasonal activities and are more or less readily fitted into ceremonial pursuits, or rather, in their less urgent periods, take on ceremonial aspects. In the ceremonial life the arts find expression, and the men and not the women are by and large the artists of the tribe.

Attached to the ceremonial life are the games of chance and

the races that are played or run at certain seasons. Here again the intermittent habit of work of the men together with their comparative mobility qualify them as gamesters and runners to the exclusion of the women. It is even more unusual to see a Pueblo woman run than to see a white American woman, and like white women, Pueblo Indian women seem quite content to pay no attention to games or merely to look on. They engage in no games.[2]

Household work is confining. Hunting, herding, trading lead to a comparatively mobile habit, a habit of mind or spirit which in the Southwest, at least, is adapted to ceremonial pursuit; for Pueblo Indian ceremonialism thrives on foreign accretions, whether of myth or song or dance or design of mask or costume, or, within certain limits of assimilation, of psychological patterns of purpose or gratification.

To the point of view that the differentiation of the sexes at Zuñi proceeds on the whole from the division of labor the native custom of allowing a boy or man to become, as far as ways of living go, a girl or woman, gives color. Towards adolescence, and sometimes in later life, it is permissible for a boy culturally to change sex. He puts on women's dress, speaks like a woman, and behaves like a woman. This alteration is due to the fact that one takes readily to women's work, one prefers it to men's work. Of one or another of the three men-women now at Zuñi or of the men-women in other pueblos I have always been told that the person in question made the change because he wanted to work like a woman or because his household was short of women and needed a woman worker. This native theory of the institution of the man-women is a curious commentary, is it not, on that thorough-going belief in the intrinsic difference between the sexes which is so tightly held to in our own culture?

[2] Formerly women are said to have played with men a ceremonial or quasi-ceremonial game, a pole and hoop game, and to-day the very little girls, besides playing house, play other games. In one of them the girls trace a spiral on the ground and at the center place a bowl of water to represent a spring. They follow the spiral to get water for their little turkeys which, they sing, are dying of thirst. A "bear" rushes out from the spring and gives chase.

# THE CONTROVERSY ON THE ORIGIN OF OUR NUMERALS

By Professor FLORIAN CAJORI

UNIVERSITY OF CALIFORNIA

RECENTLY certain articles have been written which cast doubt upon the commonly accepted view that our numeral system originated in India and two writers definitely assign a European origin.[1] As the conclusions of these articles have been spread broadcast in popular weekly journals, it seems appropriate that a fuller account giving a digest of the facts and arguments bearing on the question be placed before the scientific public.

Our so-called "Arabic" notation owes its excellence to the application of the principle of local value and the use of a symbol for zero. It is now conclusively established that the principle of local value was used by the Babylonians much earlier than by the Hindus[2] and that the Maya of Central America used the principle and symbols for zero in a well-developed numeral system of their own.[3] The notation of Babylonia used the scale of 60, that of the Maya, the scale 20 (except in one step). It follows, therefore, that the present controversy on the origin of our numerals does not involve the question of the first use of local value and symbols for zero; it concerns itself only with *the time and place of the first application of local value to the decimal scale and with the origin of the forms or shapes of our ten numerals.*

[1] G. R. Kaye, "Notes on Indian Mathematics," *Journal and Proceedings of the Asiatic Society of Bengal*, N. S., Vol. 3, 1907, pp. 475–508; "The Use of the Abacus in Ancient India," *loc. cit.*, Vol. 4, 1908, pp. 293–297; "References to Indian Mathematics in certain Mediæval Works," *loc. cit.*, Vol. 7, 1911, pp. 801–813; "A Brief Bibliography of Hindu Mathematics," *loc. cit.*, Vol. 7, 1911, pp. 679–686; *Scientia*, Vol. 24, 1918, p. 54; "Influence Grecque dans le Développement des Mathématiques Hindoues," *Scientia*, Vol. 25, 1919, pp. 1–14.

Carra de Vaux, "Sur l'origine des chiffres," *Scientia*, Vol. 21, 1917, pp. 273–282.

Nicol. Bubnov, "Arithmetische Selbstständigkeit der europäischen Kultur," Berlin, 1914. (Translated from the Russian edition, Kiev, 1908.) "Origin and History of our Numerals," Kiev, 1908 (Russian).

[2] M. Cantor, "Vorlesungen über Geschichte der Mathematik," 1. Bd., 3. Auflage, Leipzig, 1907, pp. 24–43. Cantor gives bibliographical references.

[3] C. P. Bowditch, "Maya Numeration, Calendar and Astronomy," Cambridge (Mass.), 1910; S. G. Morley, "Introduction to the Study of the Maya Hieroglyphs," Washington, 1915.

That our numerals were of Hindu origin has been the belief held by individual European writers since the Renaissance. Following the publication of M. F. Woepcke's articles, particularly his "Mémoire sur la propagation des chiffres Indiens,"[4] it came to be generally accepted by mathematical historians. Only recently have dissenting voices been heard. Three writers, G. R. Kaye, Carra de Vaux, and Nicolaus Bubnov, represent the new claims. The last two writers place the weight of their authority on the side of an European origin.

The arguments upon which the Hindu origin of our numerals has been based are essentially three in number: (1) The use of the numerals in ancient Indian inscriptions, (2) the early Indian use of the abacus, (3) the testimony of Arabic writers.

G. R. Kaye, who, on this question, is far more careful, conservative and thorough than the other two investigators, has studied the Hindu numerals in connection with the general history of mathematics in India. He has made important contributions to this subject.

As regards the first argument, relating to ancient Hindu inscriptions, Kaye refers to seventeen inscriptions antedating the tenth century A.D. which have been supposed to contain our decimal place-value notation and to indicate the Indian origin of our numerals. The inscriptions are copper-plate grants. Many such grants are now known to be forgeries, fabricated about the end of the eleventh century, when there was "great opportunity to regain confiscated endowments and to acquire fresh ones." Students of epigraphy have eliminated from these seventeen inscriptions practically all but one as unauthentic, namely the one bearing the date 867 A.D.[5] Kaye states that the two earliest known Hindu inscriptions that contain complete sets of the ten numerals are of 1050 A.D. and 1114 A.D. According to the above, the earliest period of the undoubted use of our notation in India is the ninth century of our era. If the one inscription by which the ninth century is fixed turns out to be unreliable, then we must fall back on the tenth century as the earliest period.

Some writers have ascribed a knowledge of our notation to the astronomer Aryabhatta, early in the sixth century. L. Rodet[6] does so on the ground that Aryabhatta's rule for root-

[4] *Journal Asiatique*, 6 S., T. 1., Paris, 1863, pp. 27–79, 234–290, 442–529.

[5] G. R. Kaye, *Journal and Proceedings of the Asiatic Society of Bengal*, N. S., Vol. 3, 1907, pp. 485–487.

[6] *Loc. cit.*, p. 493.

extraction implied a use of the principle of local value. "Always divide the part that is not square by twice the root of the square, after having subtracted from this squared part the square of the root: the quotient is the root to the next term." Aryabhatta gives no illustrative examples. Rodet's inference does not follow, since the rule applies to all notations. Kaye points out that Theon of Alexandria gave such a rule, yet did not use a notation with place-value.

The second argument, that the early Hindus used the abacus, is rejected by Kaye, for the reason that there is no reliable evidence to support the claim. It has been held that it was the use of the abacus which, most likely, suggested the principle of local value.

The third argument, regarding the testimony of Arabic writers, reveals in some parts the strength of Kaye's contention of a non-Hindu origin and in other parts its weakness. Kaye shows conclusively that through a mistranslation, I. Taylor and M. F. Woepcke, and their followers, have ascribed to the Hindus the use of mathematical processes in early centuries, when, as a matter of fact, there is no evidence whatever to show that the Hindus actually used these processes at so early a date. This historical error arose according to Kaye in the mistranslation of the word *hindasi*. Woepcke admits that ordinarily this word signifies "geometrical," "measure," but asserts that this interpretation seemed impossible when used in connection with an explanation of the rule of "double false position" and the process of "casting out the nines," for the reason that these processes are purely arithmetical[7] in nature. Because of the resemblance of *hindasi* to the word *hindi* or "Indian," Woepcke concluded that with the particular authors in question *hindasi* meant "Indian," and that, therefore, the "double false position" and "casting out the nines" were known to the early Hindus. The latter would seem to imply the use of our notation. But Kaye was able to show that a geometrical interpretation of the passages in question was not only possible, but had actually been found in Arabic books.[8] Moreover, authorities on the Arabic language declare that *hindasi* can not mean *hindi*. Hence, says Kaye, Woepcke's inference that the early Hindus used the method of "double false position" and the process of "casting out nine" is wholly without foundation.

[7] M. F. Woepcke, *Journal Asiatique*, 6 S., T. 1., Paris, 1863, pp. 505, 511.

[8] G. R. Kaye in *Jour. and Proceed. of the Asiatic Society of Bengal*, Vol. 7, 1911, pp. 806–811.

Kaye admits that *hindi* means only "Indian" and that there are Arabic authors who speak of "Indian" numerals and methods of computation. Some light on the probable Hindu origin was obtained only a few years ago,[9] when a passage from the Mesopotamian scholar, Severus Sebokht, indicated that in the latter half of the seventh century the nine numerals were known in Arab lands and were attributed to the Hindus. Hurt by the alleged arrogance of certain Greek scholars, Sebokht praises the science of the Hindus and speaks of "their valuable methods of computation. . . . I wish only to say that this computation is done by means of nine signs." Unfortunately, he leaves it to us to guess whether or not he used the zero. The passage, written about 662 A.D., is the earliest reference that has been found outside of India to our numerals.

About two centuries after Sebokht, appeared the famous arithmetic of the Arab Alchowarizmi. The Arabic original is lost, but a Latin translation has come down to us under the title "Algoritmi de numero Indorum." While this title refers to Indian numerals, they are not actually used in the book. A book on the astronomical tables of Alchowarizmi that was written by Muhammed ibn Ahmed el-Bîrûnî (973–1038) was translated into Hebrew by Rabbi ben Ezra, who says in his introduction that a Hindu astronomical work had been translated into Arabic and that, after the time of Alchowarizmi, "scholars do their multiplications, divisions, and extraction of roots as is written in the book of the [Hindu] scholar which they possess in translation."[10] Other Arabic authors who in the titles of their texts refer to the Hindus are enumerated by Kaye.[11] Thus, about 987 A.D. appeared "The great Treatise on the Table relating to the Indian Calculus." Soon after came "The Principles of the Indian Calculus," and about 1030 "The satisfactory Treatise on Indian Arithmetic." There were two works, both bearing the same title, "Indian Arithmetic," one of the ninth century, the other of the tenth. A Latin text, attributed to Abraham, a Jew of whom little is known, is entitled "Liber augmenti et diminutionis vocatus numeratio divinationis, ex eo quod sapientes Indi posuerunt." The Italian Leonardo of Pisa, after traveling in Egypt, Syria, Greece, Sicily, wrote in 1202 his *Liber abbaci* in which he calls our

[9] M. F. Nau, *Journal Asiatique*, S. 10, Vol. 26, 1910; D. E. Smith and J. Ginsberg, *Bulletin Am. Math. Society*, Vol. 23, 1917, p. 368.

[10] See D. E. Smith, "Rabbi ben Ezra and the Hindu-Arabic Problem," *Am. Math. Monthly*, Vol. 25, 1918, p. 103.

[11] G. R. Kaye, *Journal and Proceedings of the Asiatic Society of Bengal*, N. S., Vol. 7, 1911, pp. 814–816.

numerals with the zero "figuræ Indorum." The Byzantine monk, Maximus Planudes (1260–1330), wrote an "Arithmetic according to the Hindus." The evidence from these and some other texts that we have omitted, in favor of the Hindu origin of our numerals, is not so strong as one might think. In some cases no Hindu symbols are actually employed by the authors; the arithmetic and algebra set forth do not seem to bear Hindu characteristics. Kaye suspects that the word "Indian" was often incorrectly applied. Yet this testimony, as a whole, comes with a force that is difficult to break.

Kaye has sought light on the history of our numerals in other studies. The successive units of our notation increase from right to left. Thus, we write the present year 1919, and not 9191. Therefore, our notation was probably invented by people with a right to left script and not by the Hindus whose script is from left to right. Kaye concedes that this argument is weakened by several considerations; thus, it is known that certain scripts have reversed their direction.

Again, Kaye points out that an "Old Indian" notation without the zero was used in India as late as the twelfth and thirteenth centuries. The form of the symbols with the zero, used in India, differed so widely from the old forms without the zero used there, that the former seem to have had an independent origin and to have been imported into India.

Let us now examine the arguments put forth by the Parisian scholar, Carra de Vaux. He quotes a well-known passage from the Arabic historian Masoudi writing in 943 A.D., giving a legend on creation which De Vaux recognizes as one due, no doubt, to the Neoplatonists in Persia.[12] This legend ascribes an Indian origin to our numerals. De Vaux's contention that the belief in the Indian origin, held by modern writers on the history of mathematics, rests simply upon this legend, is hardly in accordance with fact. Too indirect or circumstantial to be convincing is de Vaux's next point. He says that the Arabic author Albiruni (died 1038) must have drawn his information about Indian numerals from the above named legend, for otherwise he would not have given simply a general statement, but would have followed his usual custom of giving almost overscrupulously precise and detailed accounts.

We have seen that Woepcke erroneously attributed to the Arabic word hindasi the significance of *hindi* or "Indian," and consequently drew some wrong conclusions. De Vaux argues

[12] See Carra de Vaux in *Scientia*, Vol. 21, 1917, p. 274. The quotation from Masoudi is given in *Jour. and Proceed. of the Asiatic Soc. of Bengal*, N. S., Vol. 7, 1911, p. 812.

the other way, namely, that *hindi* does not mean "Indian," but means hindasi or "measure," "geometry," "arithmetic." Hence, when Arabic authors speak of *hindi* numerals, they do not mean "Indian numerals." The only support advanced for this unusual and strange interpretation is that an Arabic writer of the ninth century asks the question, "who is the inventor of the *hindi* figures," implying that he did not know the answer. It is possible that the question might have meant "who *in India* is the inventor of the hindi figures." De Vaux states that the Arabs did not ascribe the abacus to India; it is called *takht*, which is said to be Persian. De Vaux conjectures that the Arabs got the numerals with the zero from the Persians, who, in turn, got them from the Neoplatonists or Neopythagorians of Greece. On this hypothesis it is easier, he says, to explain the diffusion of numerals among the different nations than on that of a Hindu origin. From the Greeks they naturally spread to the Latins (Bœthius, fifth century) and Persians, and from the Persians to the Arabs and Hindus. From the Arabs the numerals passed to Spain, where Gerbert found them in the tenth century. De Vaux's suggestions as to the parts played by Bœthius and Gerbert do not seem to give proper weight to the numerous researches on the authenticity of manuscripts and are open to grave doubts. In fact, De Vaux and Nicolaus Bubnov entertain opposite views with regard to the geometry of Bœthius, particularly the part which contains the account of the nine numerals. Bubnov[13] concludes that it was written in the eleventh century, while De Vaux assigns it to the fifth. Bubnov gave a preliminary exposition of his hypothesis on the origin of our numerals in his 1899 edition of Gerbert's mathematical works. A fuller treatment followed in his book, "The Arithmetical Independence of European Culture," which appeared in Russian in 1908 and was translated into German in 1914. In the same year 1908 he issued in Russian another publication, "Origin and History of our Numerals," We have not enjoyed the opportunity of consulting his last work directly, but a rather full synopsis is given in the *Fortschritte der Mathematik*, 1908, pp. 53, 54. Philological studies lead Bubnov to deny the Hindu origin of our numerals, to claim that in the tenth to the twelfth centuries Europe possessed the modern positional arithmetic, though clothed in the form of the abacus with columns and marked reckoning counters. Bubnov holds that these counters marked with ancient symbols (the progenitors of our numerals) had superseded the older unmarked counters. He points out the existence of a counter which stood for zero (rotula supervacua) and claims that our modern Euro-

[13] See *Fortschritte der Mathematik*, Vol. 38, 1907, p. 62.

pean numerals have no connection with India. Thus he claims that Europe possessed the modern positional arithmetic in *instrumental* form, the instrument being an abacus with columns and marked reckoning counters. He asserts with confidence that the abacus with marked counters was used by the ancient Greeks and Romans, even though (as far as known) no such counter has come down to our time or has been described by writers of antiquity. He says that when *written* arithmetic supplanted instrumental arithmetic, the nine numerals and the zero, which first appeared on counters, finally descended upon the written page, but he has no evidence to support this admittedly clever hypothesis. Nor is he able to point to any European document which contains our nine numerals and the zero as early as they are found in India. Of course, Bubnov has a perfect right to set up hypotheses of his own,but his writings display an inclination on his part to parade unproved hypotheses in the guise of fairly well established facts. That his contentions should be viewed merely as unproved hypotheses appears also from the comments made by Sintzov,[14] Smith and Karpinski,[15] Paul Tannery[16] and G. Eneström.[17]

## SUMMARY

The following are the outstanding facts:

1. The earliest reliable record of the use of our numerals with the zero is an inscription of 867 A.D. *in India.*

2. The validity of the testimony of early Arabic writers ascribing to India the numerals with the zero is shaken, but not destroyed.

3. There is not a scintilla of evidence in the form of old manuscripts or numeral inscriptions to support the Greek origin of our numerals.

4. At present the hypothesis of the Hindu origin of our numerals stands without any serious rival. But this hypothesis is by no means firmly established.

As a by-product of the discussion of recent years we must admit that, on the evidence presented, the claim that our numerals and the zero were used in India as early as the fifth century must be abandoned; our earliest apparently reliable evidence belongs to the ninth century. We must also abandon the claim that the early Hindus used the abacus, the rule of "double false position," and the process of "casting out the nines." These corrections are due to G. R. Kaye.

[14] *Fortschritte der Mathematik*, Vol. 39, 1908, p. 54.
[15] Smith and Karpinski, "Hindu-Arabic Numerals," 1911, p. 65.
[16] P. Tannery in *Bibliotheca mathematica*, 3. Series, Vol. 1, 1900, p. 286.
[17] G. Eneström in *Bibliotheca mathematica*, Vol. 14, 1913–14, p. 355.

# COLLOIDS AND LIVING PHENOMENA

By Dr. NATHAN FASTEN

THE UNIVERSITY OF WASHINGTON

IN recent years the colloids have assumed a great importance in all discussions of living matter, so much so that life has often been defined in terms of colloidal reactions. The protoplasm of the living organism consists essentially of (1) water, (2) crystalloids and (3) colloids, and it might be truly stated that all the complex and unintelligible manifestations of living matter depend, largely, on the delicate interplay of these three substances. Whether there is a vital force—an entelechy—a spirit that directs the wonderful behavior of these chemical combinations is a question which can not be conclusively answered. Certainly the results of physics, chemistry and biology within the last few years have tended to give a materialistic guidance to our conceptions of living phenomena, and many modern physiologists are in agreement with Verworn when he characterizes life as nothing more than a reaction of the proteids (colloids). In any event, it matters very little for this

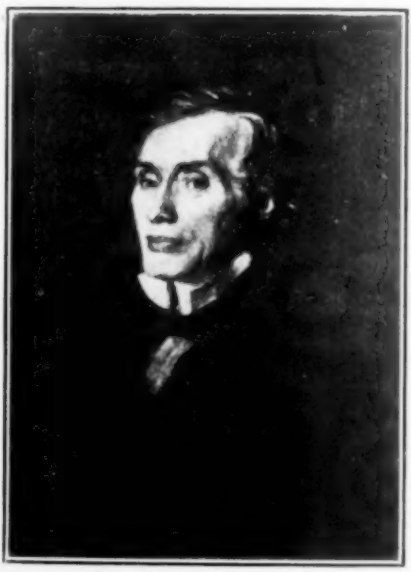


FIG. 1. THOMAS GRAHAM. (From Bayliss.)

discussion whether one's conception of life is "vitalistic" or "mechanistic." All that this paper wishes to present is the rôle played by the colloids in those unique reactions which are commonly designated as "living reactions," or as summed up in the term "life."

The colloids were first investigated by Thomas Graham (Fig. 1) in 1861, who applied the term to those substances which did not readily pass through a dialyzing membrane. To Graham the colloids and crystalloids represented two distinct worlds of matter with no transitions between them, and possessing the following well-defined properties:

*Crystalloids*

1. Are crystalline substances.
2. Form saturated solutions and crystallize out readily.
3. A saturation point is reached.
4. Are of low molecular weight.
5. Diffuse readily through animal membranes.

*Examples of Crystalloids*

Sugar, salts, fatty acids, amino-acids, glycerine, etc.

*Colloids*

1. Are amorphous substances.
2. Do not form saturated solutions and are not found to crystallize out from solution.
3. No saturation point is reached, the solution becomes thicker and thicker finally forming a viscid gum.
4. Are of very high molecular weight.
5. Diffuse but little or not at all through animal membranes.

*Examples of Colloids*

Gelatine, albumins, glue, gums, etc.

However, we now know that these are but arbitrary distinctions. While it is true that a substance in the colloidal state possesses wholly different properties than the substance in the crystalloidal state, yet it must be recognized that both are states of substances. Albumin, which exists as a colloid may, nevertheless, be obtained in a crystalline form and vice versa. Some of the commonest salts may form colloids. Thus sodium acetate possesses the qualities of a crystalloid in watery solution, while sodium stearate belongs to the colloids. Most of the typical colloids, like the proteids, may be broken down by the digestive ferments to form crystalloids. These ferments

break down the proteids into bodies intermediate between crystalloids and colloids. The proteoses, which are the first products in this metabolism, possess colloidal properties slightly less marked than the protein itself. The peptones, the next products in the breaking down process of protein, although not crystallizable, are, nevertheless, different from colloids and are true electrolytes. These are the steps that bridge the gap between colloids and crystalloids. Biochemists of to-day believe that many substances, perhaps all substances, may exist now in crystalloidal state and then in colloidal state.

This power of change from the colloidal to the crystalloidal state, and *vice versa*, seems to be the very essence of cell life. According to Wells:

> We may look upon cell life as a constant attempt at the establishment of equilibrium, both chemical and osmotic, because the move toward one sort of equilibrium is always against the other. All the food-stuffs—fats, carbohydrates and proteins—are characterized by being colloids when intact and crystalloids when disintegrated, thus:
>
> colloidal proteins $\rightleftarrows$ crystalloid amino acids,
> colloidal glycogen $\rightleftarrows$ crystalloid sugar,
> nondiffusible fats $\rightleftarrows$ diffusible soaps and glycerol.
>
> In consequence of this, if the crystalloids diffuse from the blood into a cell there is at once an excess of this end of the equation, and hastened by the intracellular enzymes, synthesis to the colloid soon occurs to establish chemical equilibrium. Chemical changes in the crystalloids, by oxidation, reduction or hydrolysis, upset this chemical equilibrium and hence further diffusion, synthesis and hydrolysis continue, one upsetting the other continuously. If equilibrium were established we should have no further reactions, and the cells would be inactive. The constant upsetting of the equilibrium is what constitutes cell life.

Perhaps the most interesting characteristic of colloidal substances is their lability. They may readily be broken down and built up into other combinations. Moore in speaking of this lability of the colloids says:

> The whole essence of the colloidal condition is that of a balance of play of energies in the most delicate equilibrium. All the known properties of colloids can be traced to feeble molecular affinities between the molecules themselves, causing them to unite into multi-molecules or "solution aggregates" and to balance between such affinities and similar feeble affinities for crystalloids in common solution with them, and for the molecules of the solvent.

Upon this lability depends the various phases undergone by the colloids in protoplasm.

Colloids are generally divided into the following phases, depending on their more liquid or jelly-like condition:

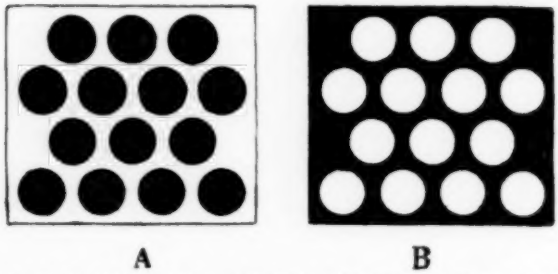



FIG. 2. DIAGRAM ILLUSTRATING PHASES IN COLLOIDAL SYSTEMS. (After Bayliss.) If the black be regarded as solid phase and the white as the liquid phase, then *A* represents a hydrosol, whereas *B* represents a hydrogel.

I. *The Hydrosols* (dispersed states.)—These are pseudo-solutions or fine suspensions. Fig. 2, *A*, represents the typical hydrosol condition.

II. *The Hydrogels* (undispersed states).—These may be either (*a*) the emulsion type, or (*b*) the coagulated or precipitated type (mixtures of emulsions). Fig. 2, *B*, represents the typical hydrogel condition.

In hydrosols the colloidal particles (or multi-molecules) are free and invisible. Each particle is distinctly separated from every other particle and behaves as a single unit or mole-

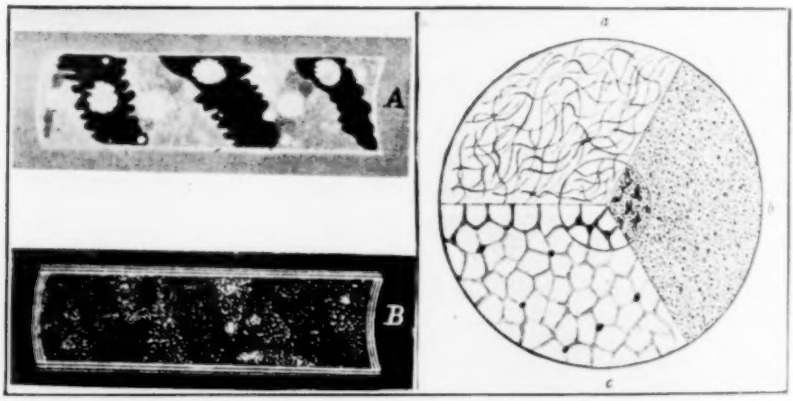



FIG. 3. CELL OF *Spirogyra*. (From Bayliss, after Gaidukov.) *A*, under ordinary microscope; *B*, under ultra-microscope.

FIG. 4. DIAGRAM ILLUSTRATING THE APPEARANCE OF PROTOPLASM WITHIN THE CELL. (After Bailey.) *a*, fibrillar structure of protoplasm; *b*, granular structure of protoplasm; *c*, foam or emulsion structure of protoplasm.

cule in solution. The particles of the colloids do not enter into true solutions, but usually exist in the form of suspensions which exhibit Brownian movement. This can be clearly seen when colloidal solutions are examined with the ultra-micro-

scope. Figs. 3, *B* and 5, *a–e* show the appearance of the suspended colloidal particles in the living cells of Spirogyra and of the dog's nervous system as seen under the ultra-microscope.

We know that most colloids form suspensions only from still another line of evidence. Substances which enter into true solution alter the freezing point as well as the boiling point of the solvent, but colloids change these points very little if at all.

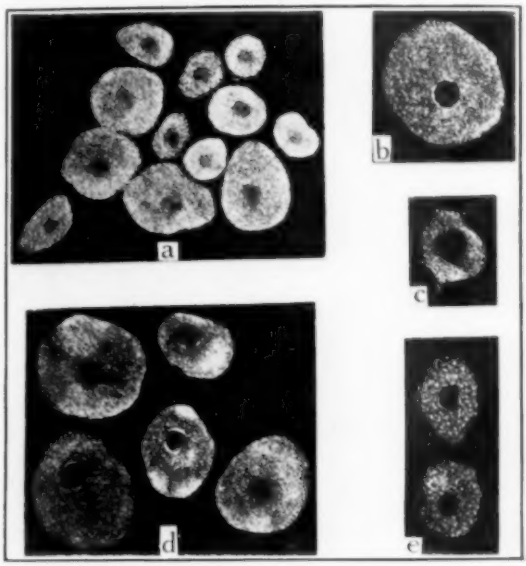



FIG. 5 (*a–e*). LIVING NERVE CELLS FROM THE DORSAL ROOT GANGLIA OF THE DOG AS SEEN WITH THE ULTRA-MICROSCOPE. The colloidal particles within the cells exhibit Brownian movements. (From Bayliss, after Marinesco.)

Furthermore, true solutions, such as formed by crystalloids, exert an osmotic pressure while suspensions show no such behavior. Typical colloids do not exert osmotic pressure, hence form no real solutions.

Some colloids, however, have been recently shown to form real solutions; for instance, Starling has shown that the proteins dissolved in the blood serum possess an osmotic pressure, hence they form true solutions. Pfeffer has also shown by his experiments on gum arabic and glue that these colloids exert osmotic pressure, therefore forming real solutions.

When, for some cause or another, such as a change in the environment of the hydrosol, the multi-molecules of the colloid are aggregated together, a hydrogel is produced. In this condition we have a diphasic system of the colloid, consisting of (1) a very dilute solution of the smaller multi-molecules, and (2) a

more or less solid of huge molecular complexes of the colloid containing comparatively little of the solvent. In forming the hydrogel there has occurred more or less of a setting of the solid colloidal particles.

When this setting of the colloidal particles has occurred in spherules far apart and separated by the fluid medium, then an emulsion is produced. If the setting continues, then a meshwork of the solid particles may be formed, enclosing the liquid phase. In this way a foam or reticulum may be produced, and the meshwork may take on many forms.

It is thus evident that in this manner the various structures found in living cells, foam structures, granular structures, networks, spindle fibers, chromosomes and the like may originate.

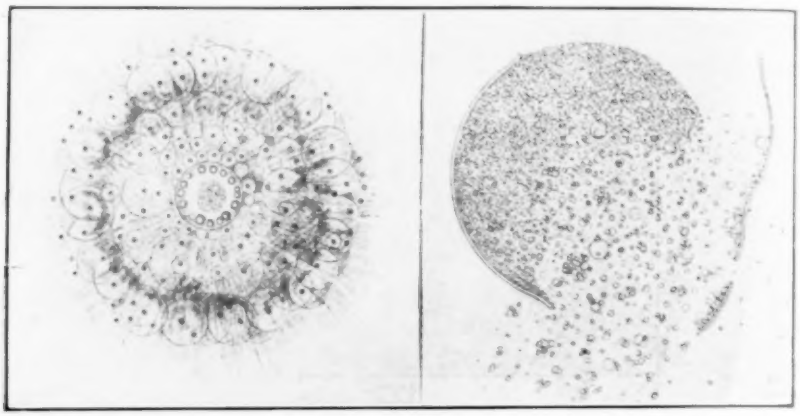


FIG. 6. THE RADIOLARIAN *Thalassicolla pelagica* HAECKEL, showing the foamy, emulsion-like character of the protoplasm. (From Doflein, after R. Hertwig.)

FIG. 7. THE EMULSION-LIKE APPEARANCE OF THE PROTOPLASM OF A RUPTURED OVUM OF *Fucus*. (After Seifriz.)

Fig. 4 illustrates the various appearances which the protoplasm of the cell may assume.

Colloidal gels are of two kinds, (1) reversible, and (2) irreversible.

A reversible gel is one in which a reversal of the condition that produced gelation causes it to return to its original state, the sol state. For example, when gelatin in the hydrosol condition is cooled it solidifies and assumes the hydrogel condition. Upon heating this hydrogel it will again assume the hydrosol condition.

On the other hand, an irreversible gel is one in which a reversal of the condition that produced gelation does not cause the colloid to return to its original condition. For instance,

when the albumen of the white of egg is heated it solidifies and assumes a gel condition. When this gel is cooled it remains unchanged and never reverts to its original hydrosol condition.

All living matter is characterized by its richness in colloids of the emulsion type (Figs. 6 and 7) which present a remarkable degree of reversibility. Protoplasm is really an aggregate of colloids holding water for the most part, in which are con-

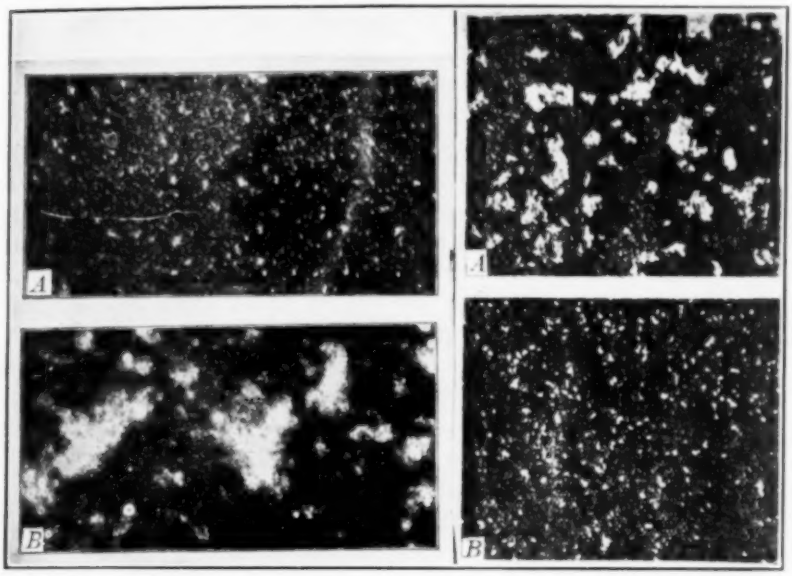



FIG. 8, *A* and *B*. TWO STAGES IN THE CLOTTING OF CASEIN, showing the aggregation of the finer colloidal particles of *A* into the coarser clumps shown in *B*. (From Mathews after Stubel.)

FIG. 9, *A* and *B*. AGGREGATION BY ELECTROLYTES OF THE BLOOD CORPUSCLES OF THE FISH *Scyllium canicula*, suspended in half-normal sodium chloride. (From Bayliss after Mines.) *A*, effect of addition of 0.0008 molar cerium chloride; *B*, effect of addition of 0.08 molar cerium chloride. The dilute solution causes aggregation by reversing the sign of the charge (from negative to positive), of a part of the corpuscles. The concentrated solution causes a rapid reversal of all the corpuscles from negative to the positive sign, causing them to remain suspended.

tained electrolytes and non-electrolytes. Hence, the chemical reactions of protoplasm occur in dilute solutions of electrolytes.

Electrolytes when in solution dissociate into ions, the positive ions, or *cations*, bearing positive charges of electricity, while the negative ions, or *anions*, bear negative charges of electricity. Thus when *NaCl* is dissolved in water, a dissociation of the *Na* and *Cl* ions occurs. The *Na* ions bear positive charges while the *Cl* ions bear negative charges. The *Na* ions are therefore *cations*, whereas, the *Cl* ions are the *anions*. Within recent years it has been found that ions may exist not

only as charged atoms, but as charged groups of atoms (radicals) as well.

Many biochemists and physiologists now believe that the physiological action of many substances depends upon the electrical charges borne by the ionized particles, and not on the chemical nature of the particles themselves.

Colloidal particles have been shown to bear electrical charges. The colloid particle, although consisting of many atoms, behaves as a single charged particle as far as its electrical charge is concerned. In general acid colloidal particles are electro-negative and alkaline colloidal particles are electro-positive. The charged particles induce the opposite charge in the surrounding water or other fluid medium in which they are suspended. If the colloidal particles are charged with positive electricity, the surrounding fluid medium is charged negatively and vice versa. Also, the number of charges in the surrounding fluid is proportional to the surface of the colloidal particle. If by any means (such as heat, electricity, internal chemical changes, etc.), the colloidal particles are thrown together into aggregations, then a reduction in the amount of surface of the particles occurs, bringing about a readjustment in the electrical conditions of the surrounding medium. Conversely, when a change occurs in the electrical state of the medium surrounding the colloidal particles, a readjustment in the latter occurs. For instance, when the density of the charge of particles is diminished aggregation leading to coagulation (Fig. 8, *A* and *B*) is brought about; when the density of the charge is increased a still finer division of the particles is produced (Fig. 9, *A* and *B*). Either change might occur as a result of the chemical changes in the particles themselves or in the conditions surrounding them.

Hardy has made a very extensive study of the electrical properties of colloids. Guyer summarizes Hardy's work as follows:

> Hardy, using a sol of proteid has shown: (1) that a gel is produced by the addition of electrolytes, but not by the addition of non-electrolytes unless they act chemically; (2) that the gelation produced by electrolytes is due to the electric charge carried by the ion, inasmuch as identical results follow the use of an electric current from a battery; (3) that the signs of the electric charges carried by the ions (plus or minus) determine the movements of colloidal particles either keeping them in suspension as a sol or causing them to fall into the gel condition (*e. g.*, a sol having its colloidal particles negatively charged will pass into a gel state if plus ions are added or if the plus electrode of a battery be introduced).

Certain daily events may be interpreted intelligently by bearing in mind the above facts. For instance, the irritability

of the human organism depends largely on the state of the colloids in the nervous system. When these colloids go into a gel condition the individual becomes irritable. When this condition is prevented irritability is lost. To take concrete examples:

1. *Mechanical stimulation* such as a shock, push, blow or electrical stimulation would cause neighboring colloidal particles on which they acted to coalesce, thus reducing their surface. Since the colloidal particles are normally positively charged, they induce the negative charge in the surrounding medium. Any reduction in the surface of the colloidal particles releases a portion of the negative charges previously induced in the fluid medium. These released negative charges act on the neighboring colloidal particles, etc. Thus a wave of gelation results, passing over the nerve, with the liberation of negative ions at the end of the process which call the muscles into play, resulting in action.

2. *Stimulation by Light and Ether Vibrations.*—Protoplasm is stimulated by light due to the charges of the electrons in the sun. When these electrons move through the ether they set up vibrations which, when they come in contact with protoplasm, act like ions, setting up a wave of gelation over the colloids in nerves, thereby bringing about a response.

3. *Chemical Stimulation.*—The action of certain chemicals, like chloroform, ether and alcohol on protoplasm may be explained on a similar basis. These substances increase the hydrosol condition, thereby preventing irritability. So long as these drugs are administered the colloidal particles of the nervous system are divided more finely, thereby causing a loss of consciousness. When these substances wear off consciousness returns. The above explains the values of ether and chloroform as anesthetics. The action of alcohol or whiskey during a snake bite may also be explained on the same grounds. Snake poison causes a coagulation of the colloidal particles. Alcohol prevents such precipitation.

On such a basis we can readily understand the rapid changes in the consistency of protoplasm—changes from more rigid conditions to those that are more fluid and vice versa. Only by understanding the reactions of the three substances entering into living combinations, namely, water, crystalloids, and colloids, can we hope to intelligently comprehend such living processes as metabolism, growth, irritability and the like. In a word "life or the life process is a reaction of the colloids," and in order to understand life or the life process the biologist of to-day must give his moments to the study of the colloids.

THE PITTSBURGH EXPERIMENT STATION OF THE BUREAU OF MINES.

## THE PROGRESS OF SCIENCE

### *DEDICATION OF THE PITTSBURGH EXPERIMENT STATION OF THE BUREAU OF MINES*

THE new experiment station of the U. S. Bureau of Mines at Pittsburgh, which has been in use for about two years, was formally dedicated to public service on September 29, the dedication ceremonies having been postponed on account of the emergency of war. E. V. Babcock, mayor of the city, welcomed the guests and official delegates and this welcome was responded to by A. T. Vogelsang, first assistant secretary of the interior, who read the following telegram from President Wilson: "Will you not be kind enough to convey my most hearty greetings to the assemblage at Pittsburgh next Monday. I wish that I might be present to express my very deep interest in the work being done by such instrumentalities for the increase of production, the safeguarding of life and the raising of the standard of labor and scientific endeavor. It is a very happy circumstance that with this meeting should be associated the ceremonies connected with the dedication of the new buildings in Pittsburgh of the Bureau of Mines."

William C. Sproul, governor of Pennsylvania, spoke of the importance of the Mining Industry in the state, of the contribution which the Bureau of Mines has made and can make to its continued progress, and pledged the cooperation of the state in every way in helping the bureau to do the things it is necessary and desirable to do in the development of the Pittsburgh station to its full usefulness. He also urged the cooperation of the men who do the work in the industry and the men who have the properties in which the work is done. J. Parke Channing, the representative of the American Institute of Mining and Metallurgical Engineers, discussed the problem of production and distribution in industry and the industrial problems of the day.

The key of the building was formally turned over to Director Van H. Manning by Assistant Secretary Vogelsang, who said that he hoped the key would never lock the building, but be regarded rather as a symbol of the purpose and the function of the bureau to unlock the secrets of nature for the use and benefits of all mankind. Mr. Manning in receiving the key said: "It is indeed to me a very high privilege to accept from you this key to this magnificent structure which has been contributed to the cause of humanity by our Government. It is an honor to be the representative who has been selected to accept this emblem which stands for safety and efficiency in the universal industry and I hereby pledge to you, Mr. Secretary, and to you who represent capital and labor, employer and employee in the mining and allied industries, my allegiance to the cause we represent."

The Pittsburgh station and its work, the development of the Bureau of Mines and the plans of its founder, Dr. J. A. Holmes, are described in an illustrated program published at the time of the dedication. It states that forming a part of the mining division of the Bureau of Mines, the coal mining section has its headquarters at the Pittsburgh Experiment Station, which is centrally situated with respect to the large coal fields of Pennsylvania, West Virginia, Ohio and other nearby states. For the purposes of organization the mining regions of the country are divided into several districts, a mining engineer being placed in charge of the work of the bureau in each district. In addition to the corps of engineers maintained at Pittsburgh under the direct supervision of the chief coal mining engineers, district engineers whose investigations pertain chiefly to coal mining are stationed at Birmingham, Ala., Vincennes, Ind., Urbana, Ill., Seattle, Wash., Golden, Colorado, and McAlester, Okla.

The mine safety section has its headquarters at Pittsburgh with safety stations also at McAlester, Okla.; Vincennes, Ind.; Birmingham, Ala.; Jellico, Tenn.; Seattle, Wash.; Norton, Va., and Berkeley, Calif. Six new all-steel cars have

THE PITTSBURGH STATION FROM THE REAR.

been built to replace the old remodeled cars, three of which, however, are still in use. Five auto trucks are also maintained for training work and for emergency use in the event of mine disaster. Other departments are the fuels section, the electrical section, the mechanical section, the chemical section, the analytical laboratory, the gas laboratory, the gas-mask laboratory, the natural gas research unit, the microscopic research unit, the petroleum laboratory, the explosives chemical laboratory, the metallurgical and metallographic laboratories, and the physical laboratory, the experimental mine near Princeton, Pa., explosive section and the administrative section.

## *THE BUREAU OF MINES AND JAMES AUSTIN HOLMES*

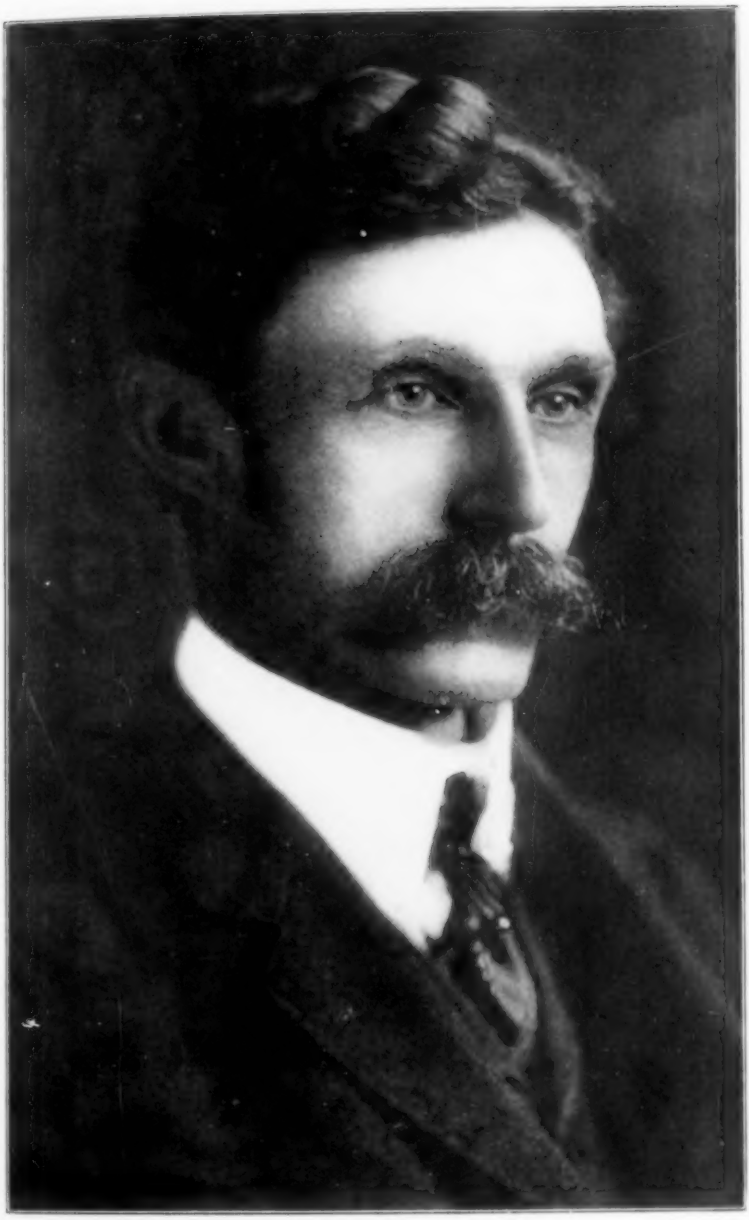
THE work of the U. S. Bureau of Mines, as defined in the legislation creating it, is to conduct scientific and technologic investigations concerning mining and the preparation of mineral substances with a view to the increase of health, safety and efficiency in the mineral industries. Its work has two phases: investigative, to determine the best procedure along these lines; and cooperative, to assist industry in utilizing to the fullest practicable degree the improved practises thus developed. To the latter end it welcomes the cooperation of operators, workmen's organizations, commercial bodies, technical societies, state and other government officials, and every one who is interested in the advancement of the mining and metallurgical industry.

The research branch has charge of investigation which is chiefly carried on in the experiment stations, although a large part is performed in the field. For purposes of technical supervision, there are five divisions of the research work; mining, metallurgical, petroleum, mechanical equipment (which includes the utilization of fuel) and mineral technology.

The operations branch carries on the cooperative work of the bureau that has been initiated by the research branch. The division of mine rescue cars and stations carries on mine rescue and first aid work at actual disasters, trains thousands of miners yearly to perform such work, and promotes interest in safety in mining through every means at its command. The division of education and information facilitates the making available to the mining public of the work done by the other branches, through publication of researches and statistics, exhibits, motion pictures, and the dissemination of information as to the laws governing the mining industry.

The foundation of the bureau was due in large measure to the efforts of the late Professor James Austin Holmes. When state geologist of North Carolina, he was chosen to organize the department of mines and metallurgy of the Louisiana Purchase Exposition at St. Louis. His creative imagination saw there an opportunity to secure results of permanent value through the analyzing and testing of the coal resources of the United States and of structural materials in connection with the exhibition, and this was done under the direction of a commission of which he was a member. After the close of the exposition the work was continued under his charge. The testing plant was subsequently transferred to the Jamestown Exposition and finally to the Arsenal grounds at Pittsburgh. In 1907 the technologic branch of the U. S. Geological Survey was organized with Dr. Holmes in charge.

At that time the United States had the unenviable distinction of



JOSEPH AUSTIN HOLMES.
The first director of the Bureau of Mines.

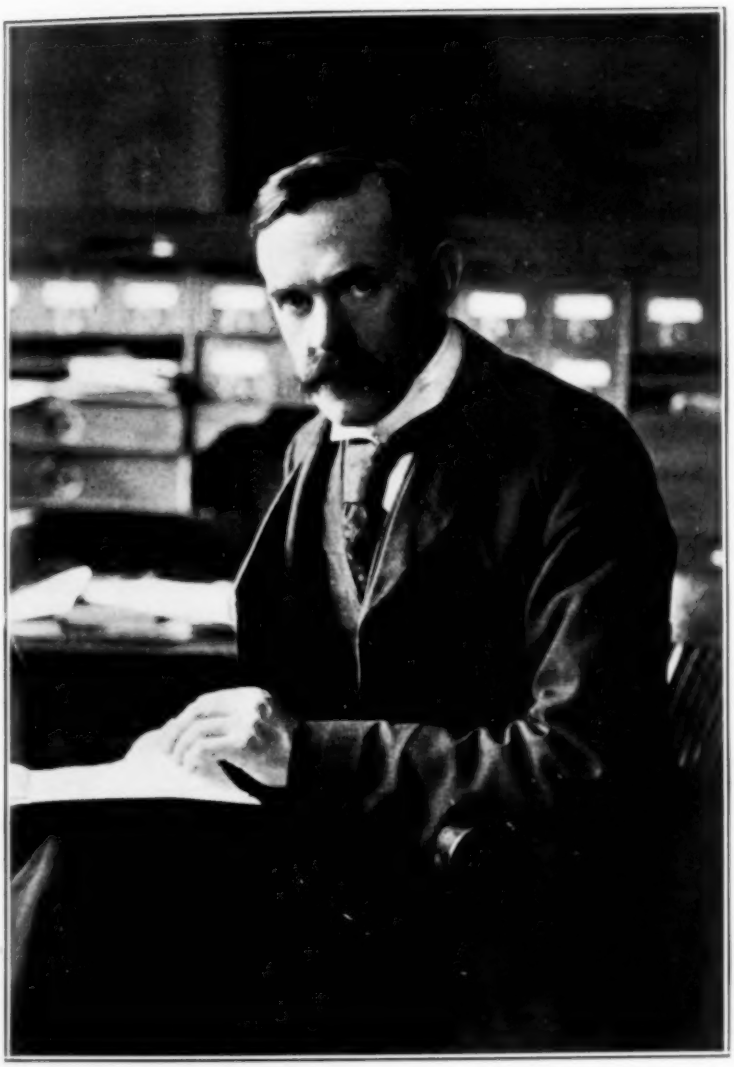
being not only the most prodigal nation in the expenditure of national resources, but of the lives of its citizens as well. Its leading place in the production of all the principal mineral substances was accompanied by a wanton loss of life and of health. In 1907 there was an unusual number of mine explosions, and the result was a general movement to take steps to prevent the needless loss of life. These culminated in the creation of the Bureau of Mines, in 1910, for the purpose of increasing health, safety, and efficiency in the mining industry. Dr. Holmes was appointed director and retained the position until his untimely death in 1915.

Starting the work at Pittsburgh placed it in the center of an important mining and metallurgical region. Though the work of the bureau was at first housed in temporary and unsuitable quarters, Dr. Holmes had a vision of a great experimental station for mining, where all kinds of accidents could be studied, and methods developed for their prevention, which miners and operators alike could feel was their station and could come to for information and education. It was also his conception that this station should help to stop the waste in mining resulting from the inefficient methods employed and the excessive competition in the coal industry. To this end he foresaw the need for research laboratories for chemical and physical investigation of gases, explosives and mineral substances, and equipment for the testing of mine lamps and other machinery, and finally, of the establishment by the bureau of such agencies as would result in the training in the use of rescue apparatus and in giving first aid to the injured. The fruition of Dr. Holmes's work is the experiment station which has now been dedicated.

## *THE BRITISH NATIONAL PHYSICAL LABORATORY AND SIR RICHARD GLAZEBROOK*

As Dr. J. A. Holmes was mainly responsible for the establishment and development of the Bureau of Mines and Dr. S. W. Stratton is for the Bureau of Standards, so in England Sir Richard Glazebrook has been director of the National Physical Laboratory since its inception. He retired on September 18, his sixty-fifth birthday, and is succeeded by Professor J. E. Petavel, professor of engineering and director of the Whitworth Laboratory in the University of Manchester.

The London *Times* remarks that "Sir Richard Glazebrook has controlled the fortunes of the National Physical Laboratory from its small beginnings in 1899 to its present great place in the scientific organization of the nation. It was first intended merely to carry out investigations required in connection with the manufacture and testing of instruments of precision, and in 1902, when it was moved to new buildings at Teddington, it had only two departments and a staff of twenty-six. It has now seven scientific departments, a secretariat, and a staff of over 600 persons. These deal with heat, optics, acoustics and molecular physics, with electricity, metrology, engineering, metallurgy, the forms of ships and aerial machines, and aero-dynamics. It gives advice on all questions involving the physical properties of matter, the strength and quality of materials, gauges and standards. During the war it rendered invaluable service. In the financial year ending in March, 1918, the Ministry of Munitions alone paid it £42,000 for work done, and the expenditure was not on manufacture, but merely on examining and testing. Until last year the Royal Society was the



Sir Richard Glazebrook,

Retiring Director of the British National Physical Laboratory.

governing body of the laboratory, and conducted its affairs with the assistance of a general board of thirty-six members, of whom twelve were nominees of industrial and commercial institutions. But the financial responsibility was heavy and increasing, and from April 1, 1918, the Department of Scientific and Industrial Research took over the burden, but assumes only the control necessary for an accounting authority. The *Times* says "Sir Richard will hand over to his distinguished successor, Professor Petavel, not only an institution of great and growing usefulness, but a tradtion of harmonious cooperation between science and industry. He has provided the new Department of Scientific and Industrial Research with a working organization sufficient to justify their existence, and with a model on which we may suppose that their most successful creations, the Industrial Research Councils, have been formed."

## *SCIENTIFIC ITEMS*

WE record with regret the death of Dr. Cyril Hopkins, head of the department of agronomy of the University of Illinois, and of Dr. August Hoch, formerly director of the Psychiatric Institute on Ward's Island, New York.

Dr. W. H. Herdman, professor of zoology in the University of Liverpool, who has been general secretary of the British Association for the Advancement of Science since 1903, has been elected president of the association.—The Willard Gibbs gold medal was presented on September 26 to Professor William A. Noyes, director of the department of chemistry at the University of Illinois, for special work in chemistry for the government performed during the war.

Mr. Arthur Balfour has been nominated for election as chancellor of Cambridge University, in succession to his brother-in-law, the late Lord Rayleigh.—William McDougall, reader in mental philosophy in Oxford University, has been elected professor of psychology at Harvard University to fill the chair vacant by the death of Hugo Münsterberg.—Mme. Curie has been appointed professor of radiology in the Warsaw University.

Professor Vito Volterra, who holds the chair of mathematical physics in the University of Rome and is a member of the Italian Senate, will deliver a series of Hitchcock lectures at the University of California from October 6 to 17. This will be the second series of Hitchcock lectures this semester, Professor W. J. V. Osterhout, of Harvard University, having just completed the first series on the general subject, "Fundamental life processes." Professor Volterra will lecture on "The propagation of electricity" and "Functional equations."